AD-A042 196 CALIFORNIA REGION.FRAMEWORK STUDY COMMITTEE F/G 8/6

COMPREHENSIVE FRAMEWORK STUDY. CALIFORNIA REGION. APPENDIX IX. --ETC(U)

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2 OF 5
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OREGON
CALIFORNIA
N
Gerber
Clear Lake
Tule Lake
Lower Klamath Lake
Lost River
KLAMATH FALLS
Klamath
Copco Lake
Iron Gate
Hyatt
HORNBROOK
Shasta River
YREKA
Dwinnell
Callahan
Scott River
Trinity River
Clair Engle Lake
(Lewiston Dam)
Indian Cr
WEAVERVILLE
Helena
North Fk
S Fk
Wooley Cr
Salmon R
New R
Schneiders Bar
Hayfork Cr
HAPPY CAMP
Indian Cr
Clear Cr
Eltapom
South Fork
Ruth Res
Dos Rios
Middle Fork
Black Butte
N Fk
Yellow Jacket
Trinity
Klamath
Redwood Creek
Mad R
Butler Valley
Van Duzen
Eel River
South Fork
MYERS FLAT
WEOTT
PEPPERWOOD-SHIVELY-HOLMES
Middle Fk
South Fk
N Fk
Smith R
Craigs
Prairie Cr
ORICK
KLAMATH-KLAMATH GLEN
CRESCENT CITY
EUREKA
Humboldt Bay
Mattole River
Cape Mendocino
1
2
3
4
5
6
8
9

LEGEND

1. Existing Projects (in operation 1965)

Reservoir or Lake

Levee & Channel Projects

1. East Weaver Cr, Trinity R
2. Eel River, Sandy Prairie Area
3. Mad River At Blue Lake

2. Potential Future Flood Control Program
A(1966-1980), A_1(Constructed or Funded for Construction as of FY'1970), B(1981-2000), C(2001-2020) (See Tables 6 & 7)

Reservoirs with Flood Control

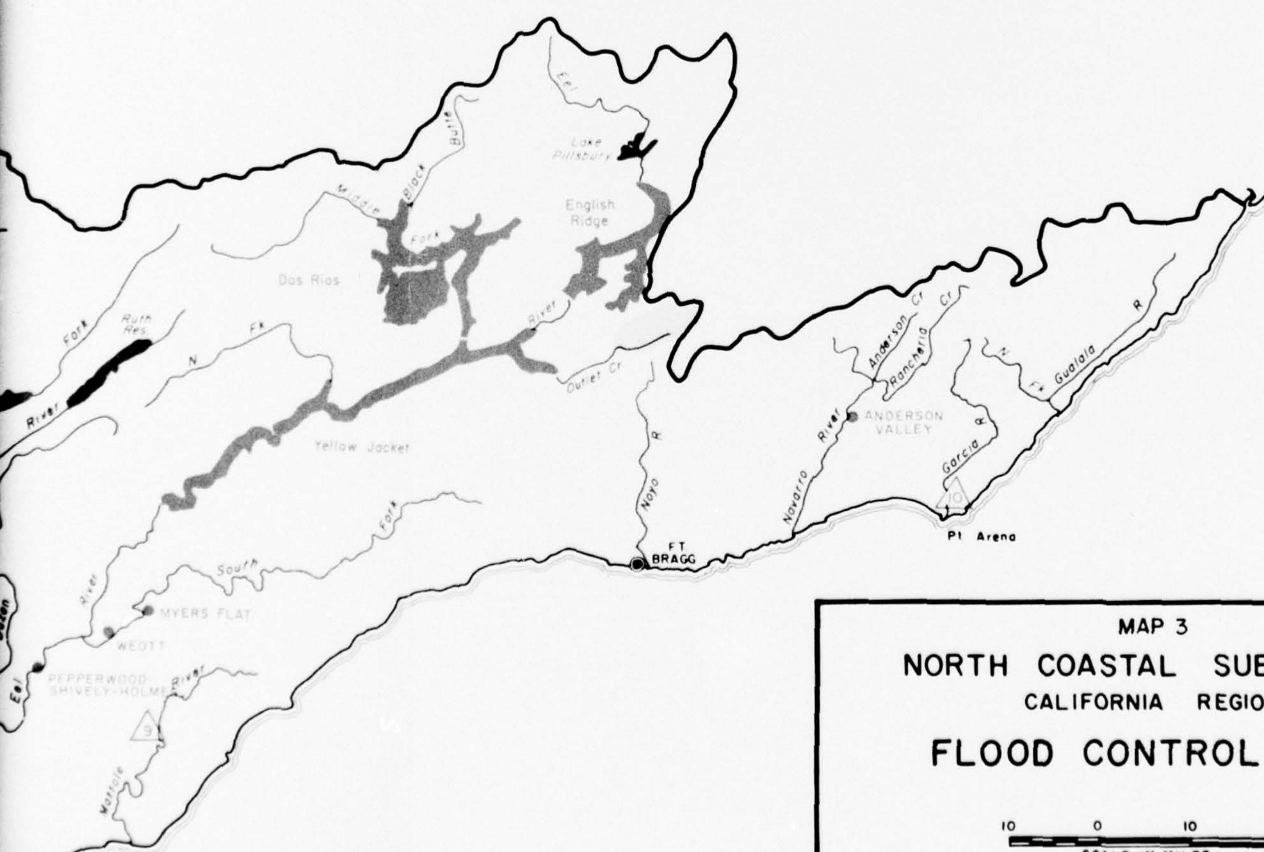
1. Butler Valley (A)
2. Callahan (B)
3. Craigs (B)
4. Helena (B)
5. Eltapom (B)
6. Schneider's Bar (B)
7. Dos Rios (B)
8. English Ridge (B)
9. Yellow Jacket (C)

Levee & Channel Projects

1. Klamath R. Near Klamath (A_1)
2. Redwood Cr. (A_1)
3. Eel River Delta Area (A)
4. Klamath R. Near Keno (A_1)
5. Coffee Creek (B)
6. Scott R. (B)
7. Van Duzen R. (B)
8. Eureka Plains (C)
9. Mattole R. (C)
10. Garcia R. (C)

Watershed Projects

Locations of Non-Structural Flood Plain Management Measures



MAP 3

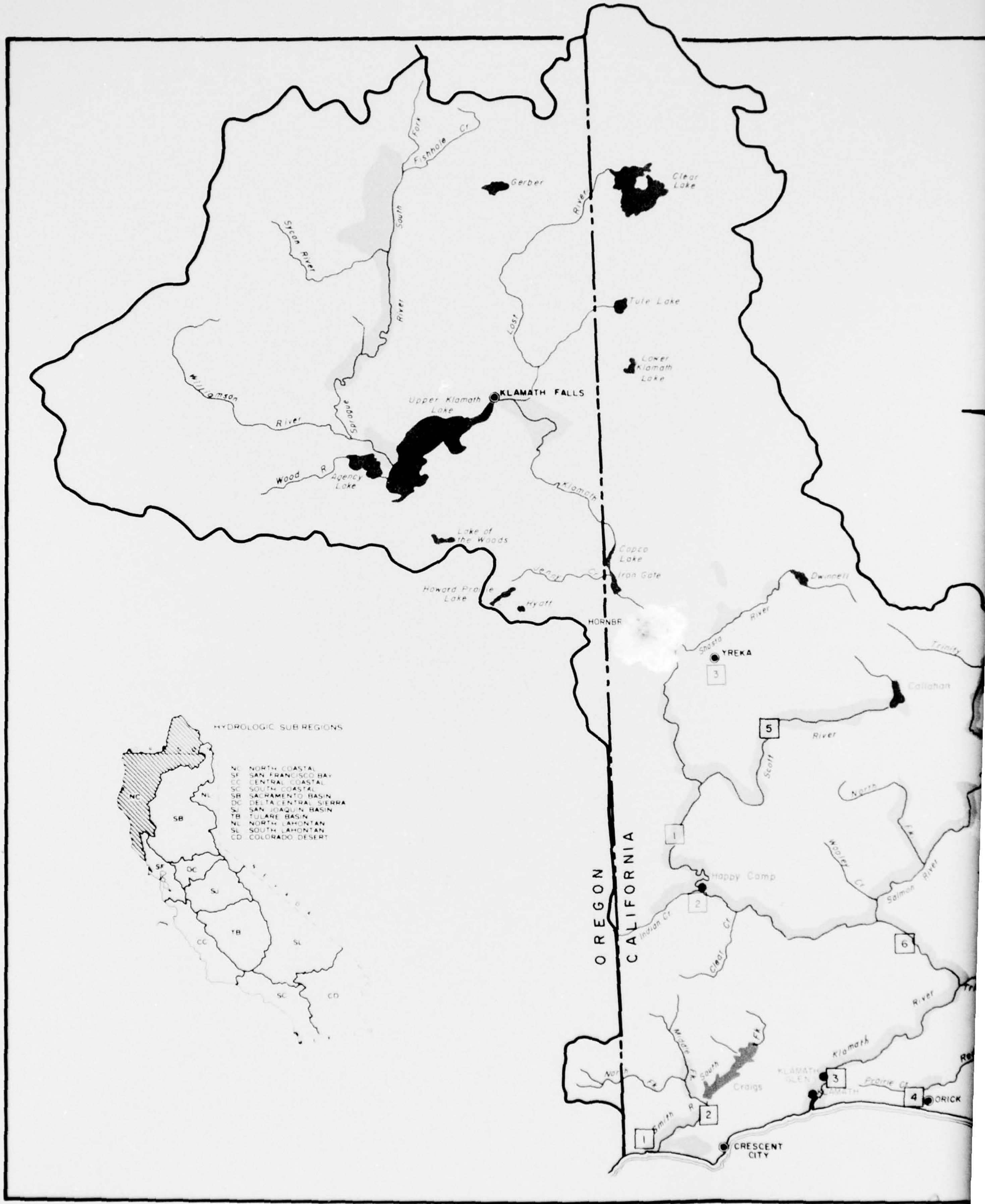
NORTH COASTAL SUBREGION

CALIFORNIA REGION

FLOOD CONTROL PLAN

10 0 10 20

SCALE IN MILES



HYDROLOGIC SUB-REGIONS
NC NORTH COASTAL
SF SAN FRANCISCO BAY
CC CENTRAL COASTAL
SC SOUTH COASTAL
SB SACRAMENTO BASIN
DC DELTA-CENTRAL SIERRA
SJ SAN JOAQUIN BASIN
TB TULARE BASIN
NL NORTH LAHONTAN
SL SOUTH LAHONTAN
CD COLORADO DESERT
OREGON
CALIFORNIA
KLAMATH FALLS
Upper Klamath Lake
Agency Lake
Wood R
Williamson River
Sprague River
South Fork
Fishhole Cr
Sycan River
Gerber
Clear Lake
Lost River
Tule Lake
Lower Klamath Lake
Klamath
Lake of the Woods
Howard Prairie Lake
Hyatt
Copco Lake
Iron Gate
Dwinnell
Shasta River
YREKA
Callahan
Scott River
Trinity
Happy Comp
Indian Cr
Clear Cr
Wooley Cr
Salmon River
North Fk
Klamath River
Middle Fk
South Fk
North Fk
Smith R
Craigs
KLAMATH GLEN
KLAMATH
Prairie Cr
ORICK
CRESCENT CITY
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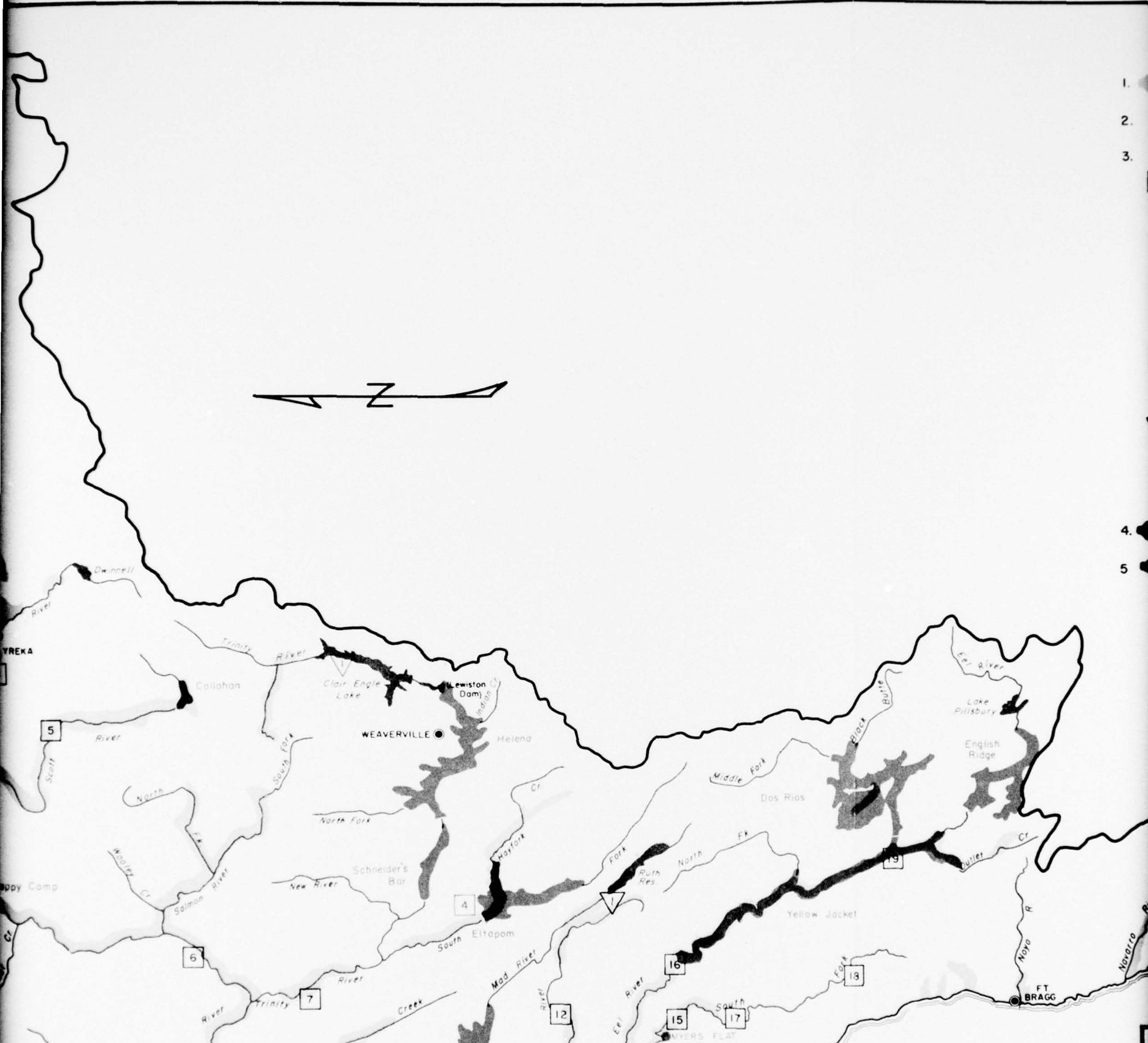


N
Dwinnell
River
YREKA
Trinity River
Callahan
Clair Engle Lake
Lewiston Dam
Indian Cr
WEAVERVILLE
Helena
5
Scott
River
South Fork
North
North Fork
Fk
Wooley Cr
Salmon River
New River
Schneider's Bar
Hayfork
Cr
4
1
Fork
Ruth Res
North Fk
Middle Fork
Black Butte
Dos Rios
Eel River
Lake Pillsbury
English Ridge
19
Outlet Cr
Yellow Jacket
South Eltapom
6
Mad River
16
Eel River
Fork
18
Noyo R
Navarro River
Trinity
River
7
Creek
12
River
15
South
17
MYERS FLAT
Klamath
Redwood
Butler Valley
BLUE LAKE
Van Duzen
14
WEOTT
13
PEPPERWOOD-SHIVELY-HOLMES
Mattole River
3
Craigs
Prairie Cr
4
ORICK
8
EUREKA
FORTUNA
10
11
SCOTIA
9
Humboldt Bay
CRESCENT CITY
FT BRAGG
Cape Mendocino

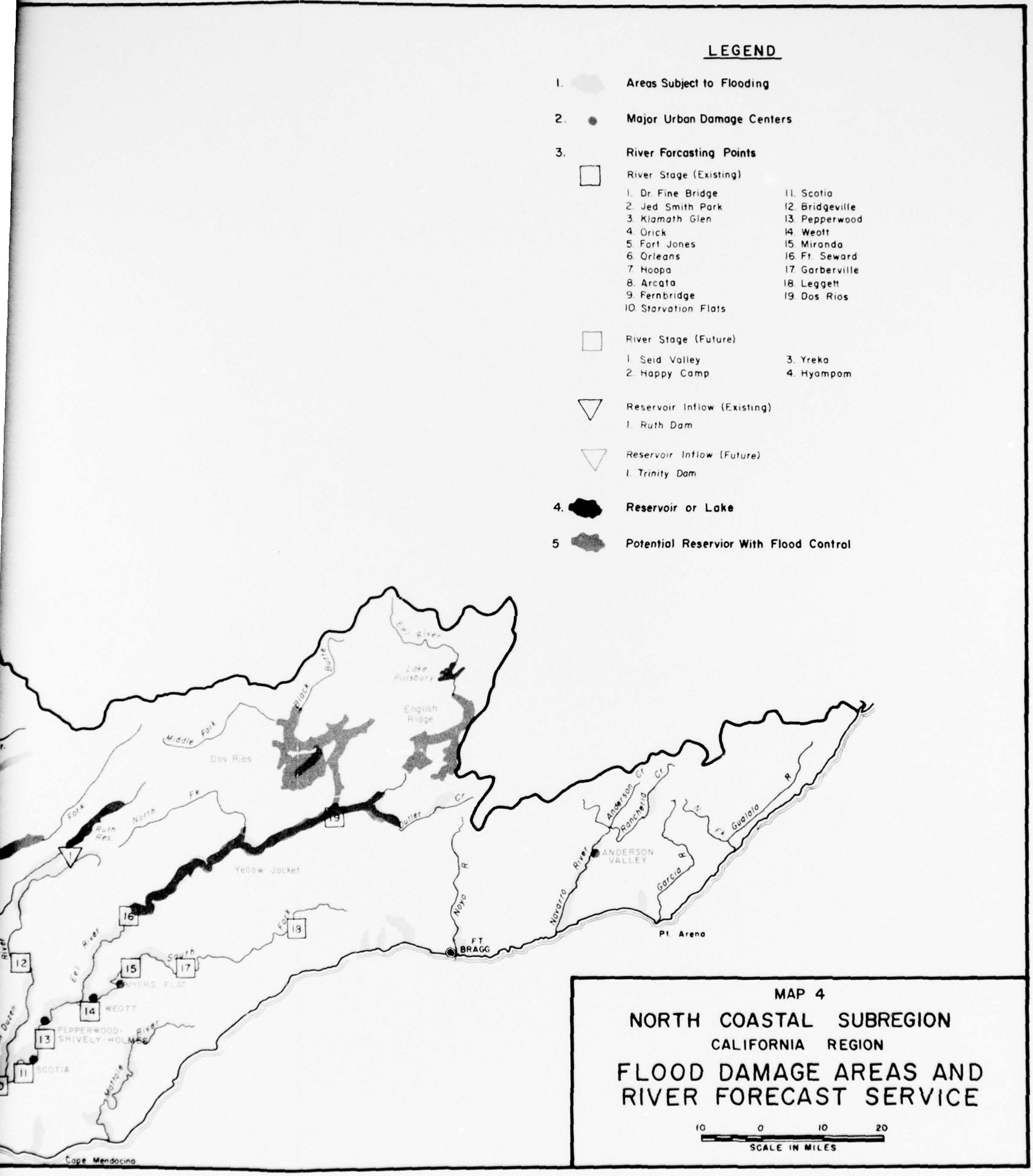
1.

2.

3.

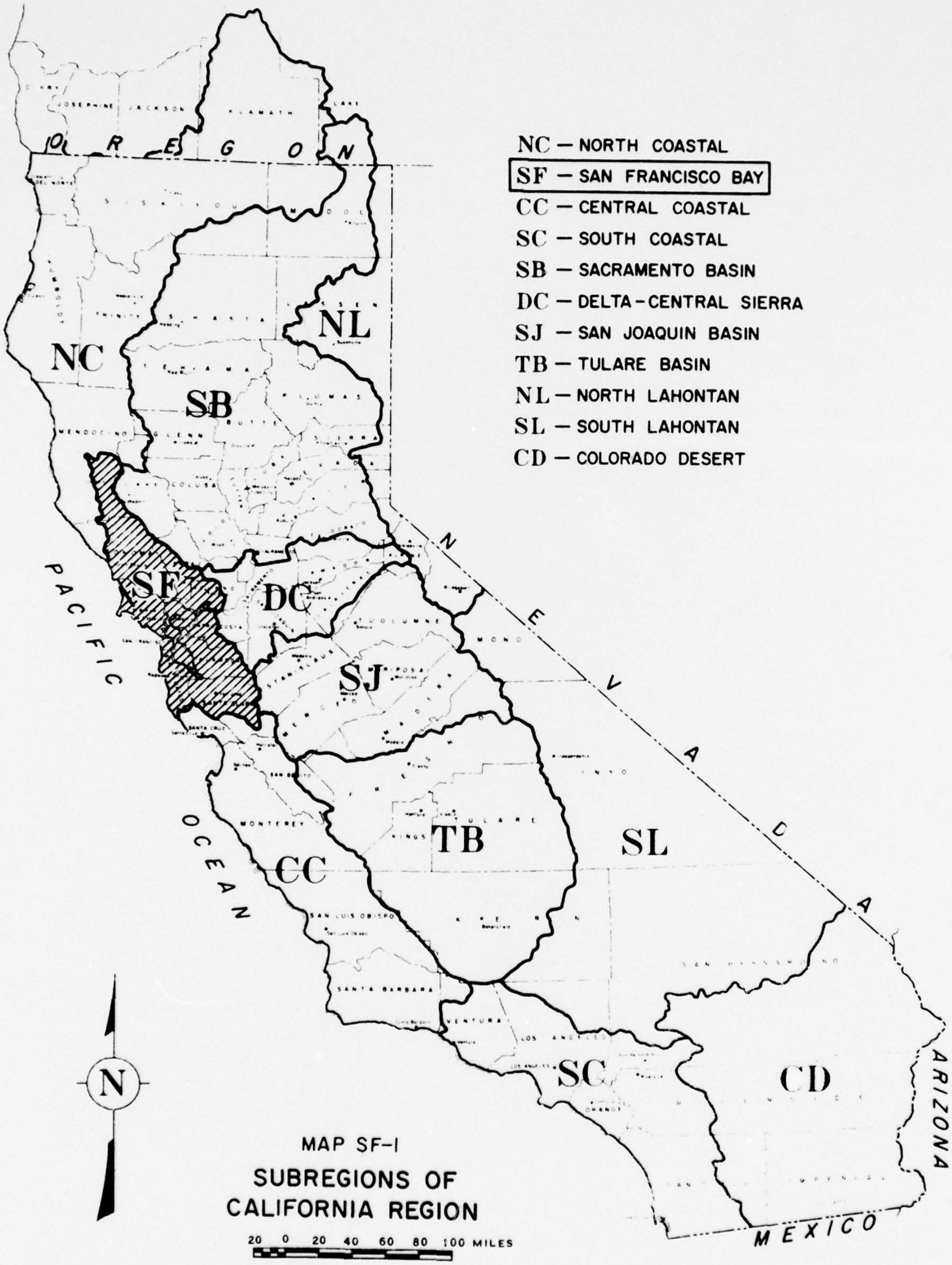
4.

5


LEGEND
1. Areas Subject to Flooding
2. Major Urban Damage Centers
3. River Forcasting Points
River Stage (Existing)
1. Dr. Fine Bridge
2. Jed Smith Park
3. Klamath Glen
4. Orick
5. Fort Jones
6. Orleans
7. Hoopa
8. Arcata
9. Fernbridge
10. Starvation Flats
11. Scotia
12. Bridgeville
13. Pepperwood
14. Weott
15. Miranda
16. Ft. Seward
17. Garberville
18. Leggett
19. Dos Rios
River Stage (Future)
1. Seid Valley
2. Happy Camp
3. Yreka
4. Hyampom
Reservoir Inflow (Existing)
1. Ruth Dam
Reservoir Inflow (Future)
1. Trinity Dam
4. Reservoir or Lake
5 Potential Reservior With Flood Control
Eel River
Lake Pillsbury
English Ridge
Black Butte
Middle Fork
Dos Rios
Fork
Ruth Res.
North Fk
19
1
Outlet Cr
Yellow Jacket
16
18
Fork
South
15
17
12
14
13
11
Eel River
River
MYERS FLAT
WEOTT
PEPPERWOOD-SHIVELY-HOLMES
SCOTIA
Mattole River
Cape Mendocino
Noyo R
FT BRAGG
Navarro River
Anderson Cr
Rancheria Cr
ANDERSON VALLEY
Garcia R
N Fk Gualala R
Pt. Arena
MAP 4
NORTH COASTAL SUBREGION
CALIFORNIA REGION
FLOOD DAMAGE AREAS AND
RIVER FORECAST SERVICE
10 0 10 20
SCALE IN MILES

3

SAN
FRANCISCO
BAY
SUBREGION



MAP SF-1

SUBREGIONS OF CALIFORNIA REGION

SAN FRANCISCO BAY SUBREGION

General

The San Francisco Bay Subregion (SF) is an area of 6,112 square miles along the central California Coast. It extends about 150 miles along the ocean from the mouth of the Russian River in Sonoma County on the north, to just south of Ano Nuevo Point in San Mateo County on the south. (See Map SF-1)

The climate of the subregion is characterized by mild, wet winters and warm, dry summers inland with cool, foggy summers along the coast. Temperatures throughout the year range from over 100 degrees to below freezing; with an average mean daily temperature of around 60 degrees. Average annual precipitation is approximately 32 inches, ranging from about 20 inches for study areas in the south to over 40 inches for the Russian River Basin to the north. Snowfall is rare and is not a contributing factor to runoff.

The subregion had an estimated population of 4 million people in 1965. Major urban centers include the metropolitan areas of San Francisco, Oakland and San Jose. The economy is dominated by highly diversified manufacturing, industrial, and service activities. Agriculture and related activities, shipping, and distribution also comprise major segments of the economy of the area.

Transportation facilities are extensive. A highly developed Federal, State and county highway and road system offers ready access to all parts of the subregion and adjoining areas. The San Francisco Subregion is served by three major railroads, and airlines providing passenger and cargo service throughout the world. There are seven major seaports, permitting ocean-going vessels to transport commercial cargoes and otherwise serve important industrial and agricultural centers.

Major streams include the Russian River, Napa River, Alameda Creek, Coyote Creek, Guadalupe River and Pescadero Creek. The Russian River is the largest stream in the subregion, draining an area of about 1,500 square miles or about 25 percent of the subregion's area. Its major tributaries are Dry Creek and Big Sulphur Creek. Additional information on the subregion can be found in Appendix II, "The Region".

Drainage basins within the subregion range from mountainous regions to flat coastal plains. These diversified hydrologic characteristics provide the basis upon which to group the streams into convenient study areas for investigative purposes. The subregion is separated into the following study areas: Russian River Basin; North Bay Stream Group; East Bay Stream Group; South Bay Stream Group; and West Bay Stream Group. These study areas with their principal streams are shown on Map 2.

History of Flooding

Recording of flood damage data prior to the early 1950's has been limited in the subregion. Floods are caused by intense rainstorms, generally preceded by rainfall that has saturated the watershed. A typical flood producing storm may last from three to six days; and actually be a rapid succession of several fronts. Peak flows, however, are generally of short duration. The frequency of flooding on the Russian River is one of the highest in the State, with most of the flooding problems occurring below Hopland, particularly in the Guerneville area.

The December 1955 and December 1964 floods are the most severe recorded in the San Francisco Bay Subregion. The two floods claimed four lives. About 90,000 acres were inundated during the 1955 flood and damages totaled nearly $23 million, about 70 percent of which were agricultural, residential and commercial losses. Total damages for the 1964 event were substantially under those of the record flood of December 1955 for the subregion as a whole. However, the Russian River Basin sustained unprecedented damage from the December 1964 flood accounting for virtually all of the reported damage from this event within the subregion. The 1964 flood inundated 33[illegible] acres in the Russian River Basin, resulting in damages of nearly $1[illegible]ion, approximately 80 percent of which were agricultural, reside[illegible] commercial losses. Included in the total damages were floo[illegible]ing and cleanup costs of approximately $1 million each for the December 1955 and December 1964 floods.

Damages from these and other significant recent floods in the subregion are summarized as follows and are shown in more detail in Tables 1 and 2. Photo SF-I shows flooding of Guerneville by the Russian River during the flood of February 1963. Photo SF-II shows flooding of Kentfield by Corte Madera Creek during the flood of February 1960.

	Flood damages 1/ ($1,000)					
Flood season (year)	Forest & range resources & facilities	Agricultural & land	Residential & commercial	Industrial & utility	Public facilities	Total
1955-56	0	6,170	9,931	3,106	3,740	22,947
1958-59	1	3,485	7,103	1,474	2,008	14,071
1962-63	0	1,838	1,475	15	240	3,568
1964-65	2	4,179	8,738	119	3,845	16,883

1/ Based on prices and project and economic conditions at time of occurrence of flood.

Flooding of Guerneville on the lower Russian River from the flood of February 1963. (Corps of Engineers Photo.)

PHOTO SF-I

Flooding of residential area of Kentfield from Corte Madera Creek in the North Bay Stream Group during flood of February 1960. (Corps of Engineers Photo.)

PHOTO SF-II

Estimated damages from a 100-year frequency flood for selected streams in the subregion are shown in Table 3. Peak flows of maximum floods of record, 100-year floods, and standard project floods for selected streams in the subregion are shown in Table 11.

Present Status of Flood Control Improvements

The existing flood control improvements within the subregion include a variety of measures to reduce floodflows. Included are flood forecasting, flood control storage, levees and channels and land treatment. For the most part, the degree of protection provided by existing measures vary from the 100-year or greater flood in urban areas and 10 to 50 year protection in agricultural areas.

The Federal-State River Forecast Center in Sacramento prepares river and flood forecasts for this subregion which are disseminated through the National Weather Service River District Office in San Francisco. These forecasts are for flood stage at key points along the Russian and Napa Rivers. Occasional warnings of potential high water are issued to interests in the San Pablo Bay reach. Forecast points are shown on Map 4.

The Russian River Basin is the only study area in the San Francisco Bay Subregion with existing (1965) flood control storage projects. Coyote Valley Reservoir provides a maximum of 48,000 acre-feet of flood storage capacity during the most critical flood situations, controlling runoff from a drainage area of 105 square miles. Numerous smaller detention structures provide an additional 5,000 acre-feet of flood detention capacity.

The existing flood control levees and channels are widely scattered and have been, for the most part, only partly effective. Existing (1965) levee and channels total 222 miles and 371 miles, respectively, as listed by study area in Table 7. The majority of these have been constructed by local interests and are of varying quality. Most of these local improvements provide protection from floods expected to occur on the average of once every 10 to 25 years. Projects with 100-year or greater flood protection account for only about 10 percent of total length of existing levee and channel improvements. Existing (1965) Federal-local protection projects include Coyote Creek in the North Bay Stream Group, and Rheem and San Lorenzo Creeks in the East Bay Stream Group.

At present watershed projects are installed on the Napa River in the North Bay Stream Group, the Russian River Basin in the vicinity of Santa Rosa and on Walnut Creek, in the East Bay Stream Group. These projects are shown on Map 3.

No flood plain information studies were prepared in the subregion prior to 1965. Currently, flood plain information reports are being prepared for several streams in the subregion. Flood hazard information has been, and is being, provided to governmental agencies to permit them to proceed with such planning, engineering studies and other action as may be necessary for wise use of flood plains. The Flood Plain Management Services Program is covered in detail in the Regional Summary of this appendix.

In tributary watersheds progress has been made in alleviating flood control problems, however, much work is still to be done. One of the subregion's remaining problems is the reduction of damages resulting from streambank erosion. Of the 2,150 bank miles of stream channels with erosion problems approximately 430 bank miles are considered as having serious problems. Work on some of the 430 bank miles of stream banks having serious erosion problems is included with levee and channel works. About one quarter of the sediment produced in this subregion comes from streambank erosion. As indicated by the tables delineating flood damages, land damage including channel and bank erosion is widespread throughout the subregion.

The accomplishments of the existing (1965) flood control measures in the San Francisco Bay Subregion have been significant. Under 1965 project and economic conditions, the flood control system would have prevented about $5 million in damages from the December 1955 flood and over $3 million in damages from the December 1964 flood. Most of this damage reduction would be credited to the Coyote Valley Reservoir in the Russian River Basin. Additional details are shown in Table 2. During the floods of 1958, Coyote Valley Reservoir, while under construction, reduced flood damages by $270,000. It was estimated that had the project been in full operation, a reduction of $530,000 would have been realized. In addition, watershed improvements on Walnut Creek and its tributaries (East Bay Stream Group) prevented an estimated $345,000 in damages to agricultural, residential and commercial properties during the 1955 flood.

While the subregion enjoys a moderate degree of flood protection, significant flood problems still exist throughout all the study areas. As indicated by the tables delineating flood damages, land damage, including channel and bank erosion, is widespread throughout the San Francisco Bay Subregion.

Average annual damages are summarized as follows for the five study areas.

Study area	Estimated Average Annual Damages ($1,000) 1/
Russian River Basin	2,280
North Bay Stream Group	2,028
East Bay Stream Group	5,458
South Bay Stream Group	1,307
West Bay Stream Group	1,027
Total San Francisco Bay Subregion	12,100

1/ Based on 1965 prices, economic and project conditions.

Additional details are contained in Tables 3 and 4 for the entire subregion and in Table 9 for urban areas. Major urban damage centers and areas of the subregion subject to flooding are shown on Map 4.

Future Needs

An examination of the tables and the previously discussed information on 1965 flood problems indicates that additional flood protection measures are required. It is estimated that average annual flood damages in the San Francisco Bay Subregion (based on 1965 prices and conditions) total $12.1 million. The flood problems are expected to increase in the future because of anticipated economic growth and change in the use of the flood plain. Population in the subregion is expected to increase from 4,061,000 in 1965, to 5,697,000 by 1980, to 8,421,000 by 2000 and 11,225,000 by 2020 (base plan projections). Due to these factors, the average annual damages are expected to increase to about $21.1 million by 1980, to $42.7 million by 2000 and $58.7 million by 2020 if additional damage reduction measures are not provided. Estimated damage data for existing and future conditions are contained in Tables 5 and 9a.

Measures Required to Satisfy Future Needs

Improved flood forecasting will be a necessary part of a comprehensive flood control program. A well-coordinated system of forecasting will permit more nearly optimum operation of projects for all purposes. The smaller streams around the San Francisco Bay will need some attention both in telemetered instrumentation and forecast procedures, particularly in the Walnut Creek and San Lorenzo Creek areas. Similar measures will also be necessary for the forecasting of floods resulting from high tides in the northern San Francisco Bay. Existing and potential river forecast points are shown on Map 4. The required improvements to the flood forecasting system have been estimated to total $150,000 for the period 1966-1980, $230,000 for 1981-2000, and $200,000 for 2001-2020.

The future flood control program will include flood water storage reservoirs with an additional 393,000 acre-feet of flood control capacity to satisfy future needs. Potential reservoirs and detention structures are listed in the following tabulation.

Study area/ time frame in which needed	Reservoir	Stream	Flood control capacity (ac.-ft.)	Drainage area (sq. miles)
Russian River Basin				
1966-1980	Warm Springs 1/	Dry Creek	130,000	130
	Knights Valley	Franz & Maacama Creeks	20,000	59
	Detention Structures (2)	(Various)	5,000	29
1981-2000	Little Sulphur	Little Sulphur Creek	36,000	32
	Redwood Valley	Russian River	13,000	14
	Mark West	Mark West Creek	26,000	34
	Mill Creek	Mill Creek	16,000	17
	Detention Structures (5)	(Various)	3,000	35
2001-2020	Robinson Creek	Robinson Creek	19,000	23
	McDowell Creek	McDowell Creek	17,000	25
	Feliz Creek	Feliz Creek	28,000	39
North Bay Stream Group				
1966-1980	Detention Structure	No Name	2,000	9
1981-2000	Detention Structures (7)	(Various)	3,000	26
East Bay Stream Group				
1966-1980	Del Valle 1/	Arroyo Valle	35,000	146
	Detention Structures (6)	(Various)	13,000	50
1981-2000	Detention Structures (4)	(Various)	3,000	20
South Bay Stream Group				
1966-1980	Detention Structure	Silver Creek	2,000	8
1981-2000	Detention Structures (3)	(Various)	3,000	14
2001-2020	Detention Structures (4)	(Various)	2,000	7

Study area/ time frame in which needed	Reservoir	Stream	Flood control capacity (ac.-ft.)	Drainage area (sq. miles)
West Bay Stream Group				
1966-1980	Worley Flat Detention Structure	Pescadero Creek	12,000	38
		No Name	5,000	12
		Total	393,000	

1/ Completed or funded for construction as of FY 1970.

Included in the above tabulation is the Knights Valley Reservoir which has been authorized for construction. In addition, local interests anticipate construction of several small reservoirs with total flood control storage of about 1,000 acre-feet in the East Bay Stream Group. These reservoirs are shown on Map 3 and additional details are contained in Table 6. Estimated cost for the additional flood control capacity totals $58.8 million for the period 1966-1980, $31.0 million for 1981-2000, and $15.4 million for 2001-2020.

These flood control reservoirs alone are not sufficient to furnish the desired degrees of protection to the subregion. Additional levee and channel improvements will be necessary to contain floodflows in those channels of limited capacity which cannot safely pass flood discharges. Preliminary studies indicate that major downstream levee and channel improvements are desirable in the following areas:

Study area/time frame in which needed	Levees 1/ (Bank Miles)	Channels 1/ (Miles)
Russian River Basin		
1966-1980	0	80
1981-2000	0	3
2001-2020	0	16
North Bay Stream Group		
1966-1980	33	77
1981-2000	6	11
East Bay Stream Group		
1966-1980	36	87
1981-2000	0	7
2001-2020	40	2

Study area/time frame in which needed	Levees 1/ (Bank Miles)	Channels 1/ (Miles)
South Bay Stream Group		
1966-1980	6	88
1981-2000	0	2
2001-2020	0	2
West Bay Stream Group		
1966-1980	0	4
1981-2000	7	14
Total	128	393

1/ Includes 35 miles of levee and 83 miles of channel which have been completed or funded for construction by FY 1970.

Local interests are expected to provide protection measures along 28 miles of channel in the Russian River Basin, 22 miles of channel in the North Bay Stream Group, 12 miles of channel in the East Bay Stream Group, 28 miles of channel in the South Bay Stream Group; and, four miles of channel in the West Bay Stream Group. Included in the above tabulations are the Napa River and Sonoma Creek Projects in the North Bay Stream Group, now in the advance engineering and design stage; and, the Alhambra Creek Project now authorized for construction. Also included is the Pine Creek watershed project which has been authorized for construction.

Locations of levees and channel work are indicated on Map 3, and additional details are included in Table 7. Estimated cost for additional levee and channel work totals $222.4 million for the period 1966-1980, $46.0 million for 1981-2000, and $18.2 million for 2001-2020.

Structural measures included in the preceeding tables will be complemented by land treatment measures. Such land treatment measures as critical area planting, brush control, farm ponds, and range seeding will be most widely used. See Map 3 for location of potential watershed projects. In areas outside of watershed project areas, throughout the subregion, individuals and groups of individuals install many land treatment measures to retard runoff and reduce erosion.

Estimated costs and acres of the above land treatment measures are tabulated on page SF-9.

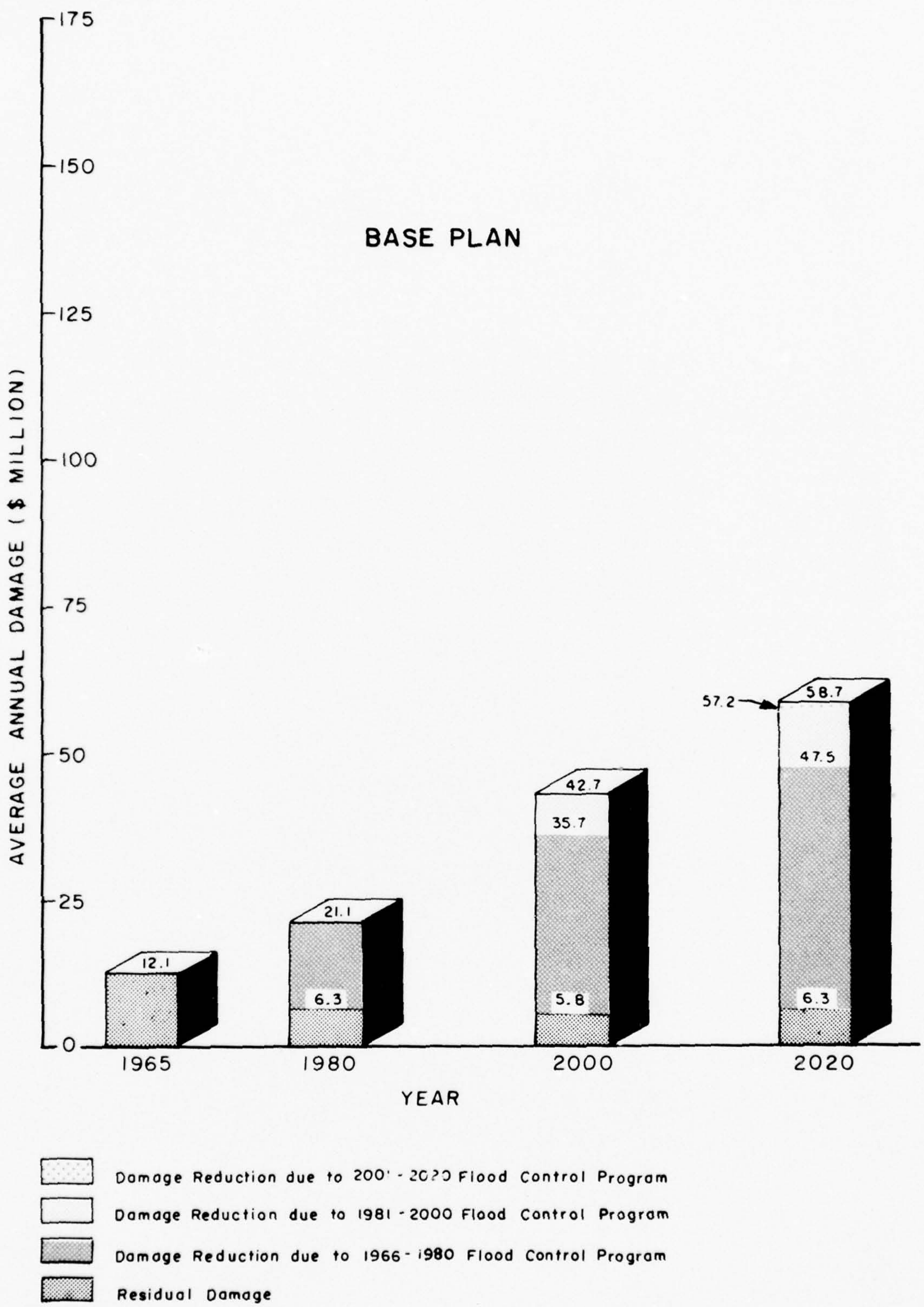
Land Treatment	1966-1980	1981-2000	2001-2020
Thousand acres	105	92	97
Thousand dollars	380	910	530

There are several communities in the subregion where flood problems exist which have not been examined in detail. These problems tentatively identified could be provided with possible solutions by the use of Flood Plain Information Reports, and other investigation programs. At the present time Flood Plain Information Studies are scheduled for several of these communities.

Within the subregion certain non-structural flood control measures were considered part of the overall program, primarily flood plain zoning and flood proofing. These were particularly applicable in the South and East Bay Stream Groups in the San Jose and the Walnut Creek areas, and involved about 50 miles of stream. Damage reductions for urban centers attributable to non-structural measures are found in Table 9b. Estimated cost for the above measures totals $4.8 million for the period 1966-1980, $16.8 million for 1981-2000 and $11.9 million for 2001-2020. The types of non-structural flood plain management measures are discussed in more detail in the Regional Summary of this appendix. (See Tables 8 and 9b).

Potential to Satisfy Future Needs

The flood control program presented herein would reduce the projected average annual damages $14.8 million by 1980, $36.9 million by 2000, and $52.4 million by 2020 at an estimated installation cost of $286.5 million for the period 1966-1980, $95.0 million for 1981-2000, and $46.3 million for 2001-2020. Estimated annual OM&R costs for the 1966-1980, 1981-2000 and 2001-2020 portion of the flood control program are $1.43 million, $0.71 million and $0.63 million. (See Tables 10, 10a and 10b). The effect of the potential flood control program on future damages is shown in Table 8 and graphically on Figure SF-1, and its effect on flood flows is shown in Table 11.



CALIFORNIA REGION
COMPREHENSIVE FRAMEWORK STUDY

PROJECTED AVERAGE ANNUAL FLOOD DAMAGES

(1965 PRICES AND PROJECT CONDITIONS-DATA FROM TABLES 5 & 8)

APPENDIX IX FIGURE SF-1

TABLE 1

SAN FRANCISCO BAY SUBREGION OF THE CALIFORNIA REGION

Historical Flood Data

Study area	Flood	Location/ flow (cfs)	Area inundated (1,000 acres)	Flood damages 1/ - ($1,000) Forest & range resources	Forest & range facilities	Crop & pasture	Other agricultural	Land	Residential & commercial	Industrial & utility	Public facilities	Total
1	2	3	4	5	6	7	8	9	10	11	12	13
Russian River Basin		Guerneville										
	Dec64	93,400	33.6	2	0	3,384	343	452	8,738	119	3,845	16,883
	Dec55	90,100	30.0	0	0	1,535	432	680	2,960	343	822	6,772
	Feb63	71,800	23.2	0	0	1,060	251	327	1,100	0	160	2,898
	Feb58	68,700	21.0	0	0	651	183	234	592	0	34	1,694
North Bay Stream Group		Napa River at St. Helena										
	Dec55	12,600	19.2	0	0	347	86	63	724	118	218	1,556
	Feb58	9,640	11.1	0	0	341	154	34	200	16	108	853
	Jan63	12,800	6.5	0	0	156	44	0	375	15	80	670
East Bay Stream Group		Alameda Creek at Niles										
	Dec55	29,000	21.8	0	0	1,054	156	22	3,348	2,645	1,559	8,784
	Apr58	19,700	18.0	0	0	638	282	32	4,016	320	1,240	6,528
South Bay Stream Group		Guadalupe River at San Jose										
	Apr58	9,150	8.5	1	0	527	337	42	1,996	670	459	4,032
		Saratoga Creek										
	Dec55	2,730	16.3	0	0	1,104	328	0	1,118	0	573	3,123
West Bay Stream Group		San Francisquito Creek at Stanford										
	Dec55	5,560	2.4	0	0	195	55	113	1,781	0	568	2,712
	Feb58	1,380	1.0	0	0	0	0	30	299	468	167	964

1/ Data based on prices and project and economic conditions at time of occurrence of flood.

TABLE 2

SAN FRANCISCO BAY SUBREGION OF THE CALIFORNIA REGION

Flood Damage 1/

Study area	Flood	Location/ flow (cfs)	Total damages - ($1,000) At time of flood 2/ Actual damage	Damage without flood control projects	Damage prevented by flood control projects 4/	1965 economic conditions & prices 3/ Damage with 1965 project conditions	Damage without flood control projects	Damage prevented by 1965 projects 5/
1	2	3	4	5	6	7	8	9
Russian River Basin		Guerneville						
	Dec64	93,400	16,883	19,883	3,000	17,308	20,385	3,077
North Bay Stream Group		Napa River at St. Helena						
	Dec55	12,600	1,556	1,556	0	2,940	3,050	110
East Bay Stream Group		Alameda Creek at Niles						
	Dec55	29,000	8,784	9,129	345	12,320	17,680	5,360
South Bay Stream Group		Saratoga Creek						
	Dec55	2,730	3,123	3,123	0	6,120	6,120	0
West Bay Stream Group		San Francisquito Creek at Stanford						
	Dec55	5,560	2,712	2,712	0	5,320	5,320	0

1/ Maximum flood for which data are available.
2/ Data based on prices and project and economic conditions at time of occurrence of flood.
3/ Data based on recurrence of original flood.
4/ Column 6 = Column 5 - Column 4
5/ Column 9 = Column 8 - Column 7

TABLE 3

SAN FRANCISCO BAY SUBREGION OF THE CALIFORNIA REGION

Estimated Flood Damage for
the 100-Year Frequency Flood 1/
for Selected Streams

Study area/ stream	Area inundated (1,000 acres)	Flood damage 2/ - ($1,000) Forest & range resources	Forest & range facilities	Crop & pasture	Other agricultural	Land	Residential & commercial	Industrial & utilities	Public facilities	Total
1	2	3	4	5	6	7	8	9	10	11
Russian River basin										
Russian River	51.4	3	0	3,634	1,013	956	11,986	156	5,162	22,910
Dry Creek	3.6	0	0	632	185	181	110	9	116	1,233
Sulphur Creek	0.1	0	0	1	3	3	1	0	3	11
Santa Rosa Creek	1.1	1	0	7	7	1	10	0	50	76
North Bay Stream Group										
Corte Madera Creek	1.4	0	0	0	0	0	2,043	146	358	2,547
Arroyo Corte Madera del Presidio	0.2	0	0	0	0	0	896	0	0	896
Novato Creek	6.0	0	0	305	86	0	1,344	47	1,008	2,790
Petaluma River	3.0	0	0	87	30	100	383	0	300	900
Sonoma Creek	8.9	0	0	349	98	119	606	88	76	1,336
Napa River	12.0	0	0	431	135	33	7,283	54	784	8,720
Fairfield Streams	4.0	0	0	19	0	0	1,901	40	20	1,980
East Bay Stream Group										
Wildcat Creek	0.9	0	0	0	0	0	1,145	932	862	2,939
San Pablo Creek	0.7	0	0	0	0	0	396	325	293	1,014
Alhambra Creek	0.5	0	0	29	8	0	2,307	0	714	3,058
Walnut Creek	7.0	0	0	56	55	17	51,657	4,144	8,725	64,654
Pine Creek Streams	4.0	0	0	12	0	0	2,190	1,880	210	4,292
San Leandro Creek	0.3	0	0	0	0	0	714	0	54	768
Alameda Creek	22.0	3	0	1,193	352	1	977	5,264	1,297	9,087
South Bay Stream Group										
Coyote River	8.5	2	0	2,788	1,485	124	3,335	1,973	701	10,408
Guadalupe River	6.6	0	0	288	81	0	3,913	9	4,655	8,946
West Bay Stream Group										
Pescadero Creek	0.9	0	0	115	33	0	183	0	338	669
San Francisquito Creek	3.3	0	0	0	0	246	8,634	0	412	9,292
San Mateo Streams	1.8	0	0	0	0	0	3,082	0	584	3,666
Colma Creek	1.0	0	0	0	0	0	1,629	0	300	1,929

1/ See Table 11 for magnitude of 100-year flood at selected stations.
2/ Based on July 1965 prices, economic conditions, and project conditions.

Base Plan

TABLE 4

SAN FRANCISCO BAY SUBREGION OF THE CALIFORNIA REGION

Estimated Average Annual Flood Damage

Study area (principal stream)	Flood damage 1/ - ($1,000) Forest & range resources	Forest & range facilities	Crop & pasture	Other agricultural	Land	Residential & commercial	Industrial & utilities	Public facilities	Study area totals
1	2	3	4	5	6	7	8	9	10
Russian River Basin (Russian River)	0	0	339	92	339	1,048	14	448	2,280
North Bay Stream Group (Napa River)	0	0	145	262	36	1,264	74	247	2,028
East Bay Stream Group (Alameda Creek)	1	0	153	54	17	3,429	1,168	636	5,458
South Bay Stream Group (Coyote River)	0	0	194	248	36	462	143	224	1,307
West Bay Stream Group (San Francisquito Creek)	0	0	52	13	14	768	0	180	1,027
Total San Francisco Bay Subregion	1	0	883	669	442	6,971	1,399	1,735	12,100

1/ Damages based on July 1965 prices, economic conditions and project conditions.

Base Plan

TABLE 5

SAN FRANCISCO BAY SUBREGION OF THE CALIFORNIA REGION

Summary of Estimated Average Annual Flood Damage for Present
and Future Conditions of Economic Development
with Existing Flood Control Measures

Study area (principal stream)	Average annual flood damages 1/ - ($1,000)			
	1965 economic conditions 2/	1980 economic conditions	2000 economic conditions	2020 economic conditions
1	2	3	4	5
Russian River Basin (Russian River)	2,280	3,521	6,491	8,526
North Bay Stream Group (Napa River)	2,028	3,463	6,973	9,391
East Bay Stream Group (Alameda Creek)	5,458	10,305	21,680	30,655
South Bay Stream Group (Coyote Creek)	1,307	2,001	3,627	4,899
West Bay Stream Group (San Francisquito Creek)	1,027	1,866	3,915	5,269
Total San Francisco Bay Subregion	12,100	21,156	42,686	58,742

1/ Damages based on July 1965 prices and project conditions and estimated economic conditions for the year shown.
2/ Figures in Column 2 are from Column 10 of Table 4.

Base Plan

TABLE 6

SAN FRANCISCO BAY SUBREGION OF THE CALIFORNIA REGION

Summary of Flood Control Capacity for Existing
and Future Reservoirs

Study area	Flood control capacity 1/ - (1,000 ac-ft)				
	Existing projects (1965)	Projects 1966-1980 2/	Projects 1981-2000 2/	Projects 2001-2020 2/	Total projects as of 2020
1	2	3	4	5	6
Russian River Basin	53	155	94	64	366
North Bay Stream Group	0	2	3	0	5
East Bay Stream Group	0	48	3	0	51
South Bay Stream Group	0	2	3	2	7
West Bay Stream Group	0	17	0	0	17
Total San Francisco Bay Subregion	53	224	103	66	446

1/ Maximum flood control capacity. Does not include surcharge storage.
2/ Includes only reservoirs controlling the 100-year flood, or better, at the damsite above urban areas and reservoirs controlling at least the 10-year flood at the damsite where only rural areas are to be protected.

Base Plan

TABLE 7

SAN FRANCISCO BAY SUBREGION OF THE CALIFORNIA REGION

Summary of Levee and Channel Flood Protection Projects
- Existing and Future -

Study area	Levee and channel projects									
	Existing projects (1965)		Projects 1966-1980 1/		Projects 1981-2000 1/		Projects 2001-2020 1/		Total projects as of 2020	
	Levees (miles)	Channels (miles)	Levees (miles)	Channels (miles)	Levees (miles)	Channels (miles)	Levees (miles)	Channels (miles)	Levees (miles)	Channels (miles)
1	2	3	4	5	6	7	8	9	10	11
Russian River Basin	6	41	0	80	0	3	0	16	6	140
North Bay Stream Group	114	54	33	77	6	11	0	0	153	142
East Bay Stream Group	30	122	36	87	0	7	40	2	106	218
South Bay Stream Group	54	63	6	88	0	2	0	2	60	155
West Bay Stream Group	18	91	0	4	7	14	0	0	25	109
Total San Francisco Bay Subregion	222	371	75	336	13	37	40	20	350	764

1/ Includes only projects giving 100-year protection, or better, to urban areas and at least 10-year flood protection to agricultural areas.

TABLE 8

SAN FRANCISCO BAY SUBREGION OF THE CALIFORNIA REGION

Estimated Average Annual Flood Damage and Damage Reduction
- Present and Future Economic Conditions -

Study area (principal stream)	Total damages - 1965 prices ($1,000)									
	1965 economic & project conditions 1/	1980 economic conditions			2000 economic conditions			2020 economic conditions		
		W/1965 project conditions 2/	Reduction in damages due to 1966-1980 flood control program 3/	Residual damage W/ 1966-1980 program 4/	W/1966-1980 program	Reduction in damages due to 1981-2000 flood control program 3/	Residual damage W/ 1981-2000 program 5/	W/1981-2000 program	Reduction in damages due to 2001-2020 flood control program 3/	Residual damage W/ 2001-2020 program 6/
1	2	3	4	5	6	7	8	9	10	11
Russian River Basin (Russian River)	2,280	3,521	1,724	1,797	3,370	1,353	2,017	2,667	825	1,842
North Bay Stream Group (Napa River)	2,028	3,463	2,708	755	1,537	857	680	895	113	782
East Bay Stream Group (Alameda Creek)	5,458	10,305	8,869	1,436	3,023	1,149	1,874	2,618	495	2,123
South Bay Stream Group (Coyote River)	1,307	2,001	1,301	700	1,308	356	952	1,285	90	1,195
West Bay Stream Group (San Francisquito Creek)	1,027	1,866	239	1,627	3,524	3,274	250	332	0	332
Total San Francisco Bay Subregion	12,100	21,156	14,841	6,315	12,762	6,989	5,773	7,797	1,523	6,274

1/ Figures shown in Column 2 are from Column 10 of Table 4 and are also shown in Column 2 of Table 5.
2/ Figures in Column 3 are from Column 3 of Table 5.
3/ Includes structural and non-structural measures.
4/ Column 5 = Column 3 - Column 4.
5/ Column 8 = Column 6 - Column 7.
6/ Column 11 = Column 9 - Column 10.

TABLE 9

SAN FRANCISCO BAY SUBREGION OF THE CALIFORNIA REGION

Estimated Average Annual Flood Damage for Urban Areas with Significant Flood Problems

Study area/ stream	Damage center	Average annual flood damages ($1,000) 1/ Residential	Commercial	Industrial & utilities	Public facilities	Total
1	2	3	4	5	6	7
Russian River Basin						
Russian River	Guerneville	620	290	9	225	1,144
North Bay Stream Group						
Sonoma Creek	Sonoma	61	41	14	9	125
Napa River	Napa	99	270	2	34	405
Novato Creek	Novato	50	71	5	91	217
Petaluma River	Petaluma	18	18	0	28	64
San Rafael Creek	San Rafael	37	76	0	0	113
Corte Madera Creek	Kentfield	125	101	16	41	283
Arroyo Corte Madera del Presidio	Mill Valley	35	55	0	9	99
Fairfield Streams	Fairfield	165	2	2	1	170
Subtotal		590	634	39	213	1,476
East Bay Stream Group						
Walnut Creek	Walnut Creek	1,880	366	115	315	2,676
Pine Creek	Concord	336	84	464	40	924
Alhambra Creek	Martinez	72	35	0	33	140
Wildcat and San Pablo Creeks	San Pablo	15	44	48	43	150
San Leandro Creek	San Leandro	22	0	9	2	33
Rodeo Creek	Rodeo	27	15	0	2	44
Pinole Creek	Pinole	11	2	1	12	26
Mt. Diablo Creek	Concord	86	43	34	9	172
Temescal	Emeryville	1	0	78	31	110
Alameda Creek	Pleasanton	6	2	47	12	67
	Fremont	47	16	341	78	482
Kirker Creek	Pittsburg	124	53	22	22	221
Subtotal		2,627	660	1,159	599	5,045
South Bay Stream Group						
Matadero-Adobe-Barron Creeks	Palo Alto	23	12	5	7	47
Stevens	Mountain View	9	5	0	8	22
Guadalupe River	San Jose	90	27	NEG	139	256
Coyote Creek	East San Jose	24	7	1	18	50
Miscellaneous Streams	East San Jose 2/	160	35	137	26	358
Subtotal		306	86	143	198	733
West Bay Stream Group						
San Francisquito Creek	Palo Alto	348	56	0	20	424
Colma Creek	South San Francisco	7	186	0	36	229
Pescadero Creek	Pescadero	14	4	0	33	51
San Mateo Streams	San Mateo	128	14	0	27	169
Subtotal		497	260	0	116	873
Total San Francisco Bay Subregion		4,640	1,930	1,350	1,351	9,271

1/ Damages are based on July 1965 prices, economic conditions, and project conditions.
2/ Includes Silver Creek, San Felipe Creek, Upper Penitencia Creek, Parkwood Creek, Canada Creek, Hoover Creek, and Las Animas Creek.

TABLE 9a

SAN FRANCISCO BAY SUBREGION OF THE CALIFORNIA REGION

Summary of Estimated Average Annual Flood Damage for Urban Areas with Significant Flood Problems
- Present and Future Conditions of Economic Development
with Existing Flood Control Measures -

Study area/ stream	Damage center	Average annual flood damages 1/ - ($1,000) 1965 economic conditions 2/	1980 economic conditions	2000 economic conditions	2020 economic conditions
1	2	3	4	5	6
Russian River Basin					
Russian River	Guerneville	1,144	2,153	4,604	6,240
North Bay Stream Group					
Sonoma Creek	Sonoma	125	245	535	739
Napa River	Napa	405	790	1,740	2,359
Novato Creek	Novato	217	379	756	1,026
Petaluma River	Petaluma	64	111	221	298
San Rafael Creek	San Rafael	113	226	509	689
Corte Madera Creek	Kentfield	283	541	1,168	1,600
Arroyo Corte Madera del Presidio	Mill Valley	99	193	425	575
Fairfield Streams	Fairfield	170	339	762	1,034
Subtotal		1,476	2,824	6,116	8,320
East Bay Stream Group					
Walnut Creek	Walnut Creek	2,676	5,163	11,229	15,342
Pine Creek	Concord	924	1,824	3,830	5,736
Alhambra Creek	Martinez	140	260	551	745
Wildcat and San Pablo Creeks	San Pablo	150	274	548	797
San Leandro Creek	San Leandro	33	65	139	190
Rodeo Creek	Rodeo	44	87	194	263
Pinole Creek	Pinole	26	45	68	120
Mt. Diablo Creek	Concord	172	339	745	1,053
Kirker Creek	Pittsburg	221	429	931	1,286
Temescal	Emeryville	110	201	382	608
Alameda Creek	Pleasanton	67	127	249	393
	Fremont	482	922	1,812	2,854
Subtotal		5,045	9,736	20,698	29,387
South Bay Stream Group					
Matadero-Adobe-Barron Creeks	Palo Alto	47	90	193	267
Stevens	Mountain View	22	39	80	107
Guadalupe River	San Jose	256	429	819	1,103
Coyote Creek	*East San Jose*	50	89	182	246
Miscellaneous Streams	East San Jose 3/	358	700	1,481	2,157
Subtotal		733	1,347	2,755	3,890
West Bay Stream Group					
San Francisquito Creek	Palo Alto	424	836	1,860	2,521
Colma Creek	South San Francisco	229	436	945	1,279
Pescadero Creek	Pescadero	51	82	150	201
San Mateo Streams	San Mateo	169	322	696	942
Subtotal		873	1,676	3,651	4,943
Total San Francisco Bay Subregion		9,271	17,736	37,824	52,780

1/ Damages based on July 1965 prices and project conditions and estimated economic conditions for the year shown.
2/ Figures in Column 3 are from Column 7 of Table 9.
3/ Includes Silver Creek, San Felipe Creek, Upper Penitencia Creek, Parkwood Creek, Canada Creek, Hoover Creek and Las Animas Creek.

TABLE 9b

SAN FRANCISCO BAY SUBREGION OF THE CALIFORNIA REGION

Estimated Average Annual Flood Damage and Damage Reduction
for Urban Areas With Significant Flood Problems
- Present and Future Economic Conditions -

Total damages - 1965 prices ($1,000)

Study area/ stream	Damage center	1965 economic & project conditions 1/	1980 economic conditions: W/1965 project conditions 2/	1980: Reduction due to 1966-1980 program: Non-structural measures	1980: Reduction due to 1966-1980 program: Structural measures	1980: Residual damage w/1966-1980 program 3/	2000 economic conditions: W/1966-1980 program	2000: Reduction due to 1981-2000 program: Non-structural measures	2000: Reduction due to 1981-2000 program: Structural measures	2000: Residual damage w/1981-2000 program 4/	2020 economic conditions: W/1981-2000 program	2020: Reduction due to 2001-2020 program: Non-structural measures	2020: Reduction due to 2001-2020 program: Structural measures	2020: Residual damage w/2001-2020 program 5/
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Russian River Basin														
Russian River	Guerneville	1,144	2,153	0	1,234	919	1,967	0	1,141	826	1,125	200	301	622
North Bay Stream Group														
Sonoma Creek	Sonoma	125	245	0	203	42	94	0	0	94	130	25	0	105
Napa River	Napa	405	790	0	766	24	53	0	0	53	72	0	0	72
Novato Creek	Novato	217	379	0	377	2	4	0	0	4	5	0	0	5
Petaluma River	Petaluma	64	111	0	0	111	221	0	199	22	30	0	0	30
San Rafael Creek	San Rafael	113	226	0	0	226	509	0	484	25	34	0	0	34
Corte Madera Creek	Kentfield	283	541	0	528	13	28	0	0	28	38	0	0	38
Arroyo Corte Madera del Presidio	Mill Valley	99	193	0	190	3	7	0	0	7	9	0	0	9
Fairfield Stream	Fairfield	170	339	0	316	23	52	0	0	52	71	0	0	71
Subtotal		1,476	2,824	0	2,380	444	968	0	683	285	389	25	0	364
East Bay Stream Group														
Walnut Creek	Walnut Creek	2,676	5,163	0	4,378	785	1,703	658	0	1,045	1,432	241	0	1,191
Pine Creek	Concord	924	1,824	0	1,823	1	2	0	0	2	3	0	0	3
Alhambra Creek	Martinez	140	260	0	258	2	4	0	0	4	5	0	0	5
Wildcat and San Pablo Creeks	San Pablo	150	274	0	271	3	8	0	0	8	11	0	0	11
Kirker Creek	Pittsburg	221	429	0	113	316	686	274	0	412	569	111	0	458
San Leandro Creek	San Leandro	33	65	0	64	1	2	0	0	2	3	0	0	3
Rodeo Creek	Rodeo	44	87	0	85	2	4	0	0	4	5	0	0	5
Pinole Creek	Pinole	26	45	0	44	1	2	0	0	2	3	0	0	3
Mt. Diablo Creek	Concord	172	339	0	338	1	1	0	0	1	1	0	0	1
Temescal	Emeryville	110	201	0	181	20	38	0	0	38	60	0	0	60
Alameda Creek	Pleasanton	67	128	0	58	70	138	0	0	138	218	0	155	63
	Fremont	482	921	0	861	60	119	0	0	119	188	0	0	188
Subtotal		5,045	9,736	0	8,474	1,262	2,707	932	0	1,775	2,498	352	155	1,991
South Bay Stream Group														
Matadero-Adobe-Barron Creeks	Palo Alto	47	90	0	0	90	193	0	166	27	37	0	0	37
Stevens	Mountain View	22	39	0	0	39	80	0	0	80	107	C	0	107
Guadalupe River	San Jose	256	429	72	188	169	323	0	0	323	436	81	0	. 355
Coyote Creek	East San Jose	50	89	0	81	8	16	0	0	16	22	0	0	22
Miscellaneous Streams 6/	East San Jose	358	700	210	245	245	519	186	0	333	486	0	0	486
Subtotal		733	1,347	282	514	551	1,131	186	166	779	1,088	81	0	1,007
West Bay Stream Group														
San Francisquito Creek	Palo Alto	424	836	0	0	836	1,860	0	1,840	20	26	0	0	26
Colma Creek	South San Francisco	229	436	0	0	436	945	0	898	47	63	0	0	63
Pescadero Creek	Pescadero	51	82	0	81	1	2	0	0	2	3	0	0	3
San Mateo Streams	San Mateo	169	322	27	0	295	637	0	523	114	154	0	0	154
Subtotal		873	1,676	27	81	1,568	3,444	0	3,261	183	246	0	0	246
Total San Francisco Bay Subregion		9,271	17,736	309	12,683	4,744	10,217	1,118	5,251	3,848	5,344	658	456	4,230

1/ Figures shown in Column 3 are from Column 7 of Table 9 and are also shown in Column 3 of Table 9a.
2/ Figures in Column 4 are from Column 4 of Table 9a.
3/ Column 7 = Column 4 - Column 5 - Column 6.
4/ Column 11 = Column 8 - Column 9 - Column 10.
5/ Column 15 = Column 12 - Column 13 - Column 14.
6/ Includes Silver Creek, San Felipe Creek, Upper Penitencia Creek, Parkwood Creek, Canada Creek, Hoover Creek and Las Animas Creek.

TABLE 10

SAN FRANCISCO BAY SUBREGION OF THE CALIFORNIA REGION

Estimated Costs of Future Flood Control Program
- 1966 to 1980 -
($1,000)

Study area	Levees & channels				Flood control reservoirs				Non-structural measures			
	Federal		Non-Federal		Federal		Non-Federal		Federal		Non-Federal	
	Installation costs	Annual OM&R costs	Installation costs	Annual OM&R costs	Installation costs	Annual OM&R costs	Installation costs	Annual OM&R costs	Installation costs	Annual OM&R costs	Installation costs	Annual OM&R costs
1	2	3	4	5	6	7	8	9	10	11	12	13
Russian River Basin	4,430	0	4,730	71	27,990	142	270	19	50	26	200	36
North Bay Stream Group	45,150	0	12,820	186	1,300	0	740	33	30	14	50	10
East Bay Stream Group	71,970	0	34,460	306	20,370	65	1,970	23	10	6	120	26
South Bay Stream Group	810	0	45,100	403	260	0	200	2	150	1	4,300	32
West Bay Stream Group	0	0	2,880	11	4,530	2	1,140	13	30	1	410	5
Total San Francisco Bay Subregion	122,360	0	99,990	977	54,450	209	4,320	90	270	48	5,080	109

TABLE 10a

SAN FRANCISCO BAY SUBREGION OF THE CALIFORNIA REGION

Estimated Costs of Future Flood Control Program
- 1981 to 2000 -
($1,000)

Study area	Levees & channels				Flood control reservoirs				Non-structural measures			
	Federal		Non-Federal		Federal		Non-Federal		Federal		Non-Federal	
	Installation costs	Annual OM&R costs	Installation costs	Annual OM&R costs	Installation costs	Annual OM&R costs	Installation costs	Annual OM&R costs	Installation costs	Annual OM&R costs	Installation costs	Annual OM&R costs
1	2	3	4	5	6	7	8	9	10	11	12	13
Russian River Basin	90	0	50	3	22,000	91	1,380	6	50	35	450	79
North Bay Stream Group	7,140	0	1,850	78	3,320	0	190	16	20	21	100	20
East Bay Stream Group	1,960	0	70	21	2,450	0	60	9	60	26	14,140	109
South Bay Stream Group	230	0	40	8	1,230	0	400	3	30	12	2,930	40
West Bay Stream Group	29,300	0	5,300	100	0	0	0	0	40	12	120	24
Total San Francisco Bay Subregion	38,720	0	7,310	210	29,000	91	2,030	34	200	106	17,740	272

TABLE 10b

SAN FRANCISCO BAY SUBREGION OF THE CALIFORNIA REGION

Estimated Costs of Future Flood Control Program
- 2001 to 2020 -
($1,000)

Study area	Levees & channels				Flood control reservoirs				Non-structural measures			
	Federal		Non-Federal		Federal		Non-Federal		Federal		Non-Federal	
	Installation costs	Annual OM&R costs	Installation costs	Annual OM&R costs	Installation costs	Annual OM&R costs	Installation costs	Annual OM&R costs	Installation costs	Annual OM&R costs	Installation costs	Annual OM&R costs
1	2	3	4	5	6	7	8	9	10	11	12	13
Russian River Basin	3,400	0	190	78	14,700	73	0	0	40	44	3,970	69
North Bay Stream Group	0	0	0	0	0	0	0	0	20	26	1,760	26
East Bay Stream Group	3,840	0	9,920	119	0	0	0	0	30	35	5,370	64
South Bay Stream Group	790	0	70	3	630	0	100	1	30	22	1,300	29
West Bay Stream Group	0	0	0	0	0	0	0	0	30	21	80	21
Total San Francisco Bay Subregion	8,030	0	10,180	200	15,330	73	100	1	150	148	12,480	209

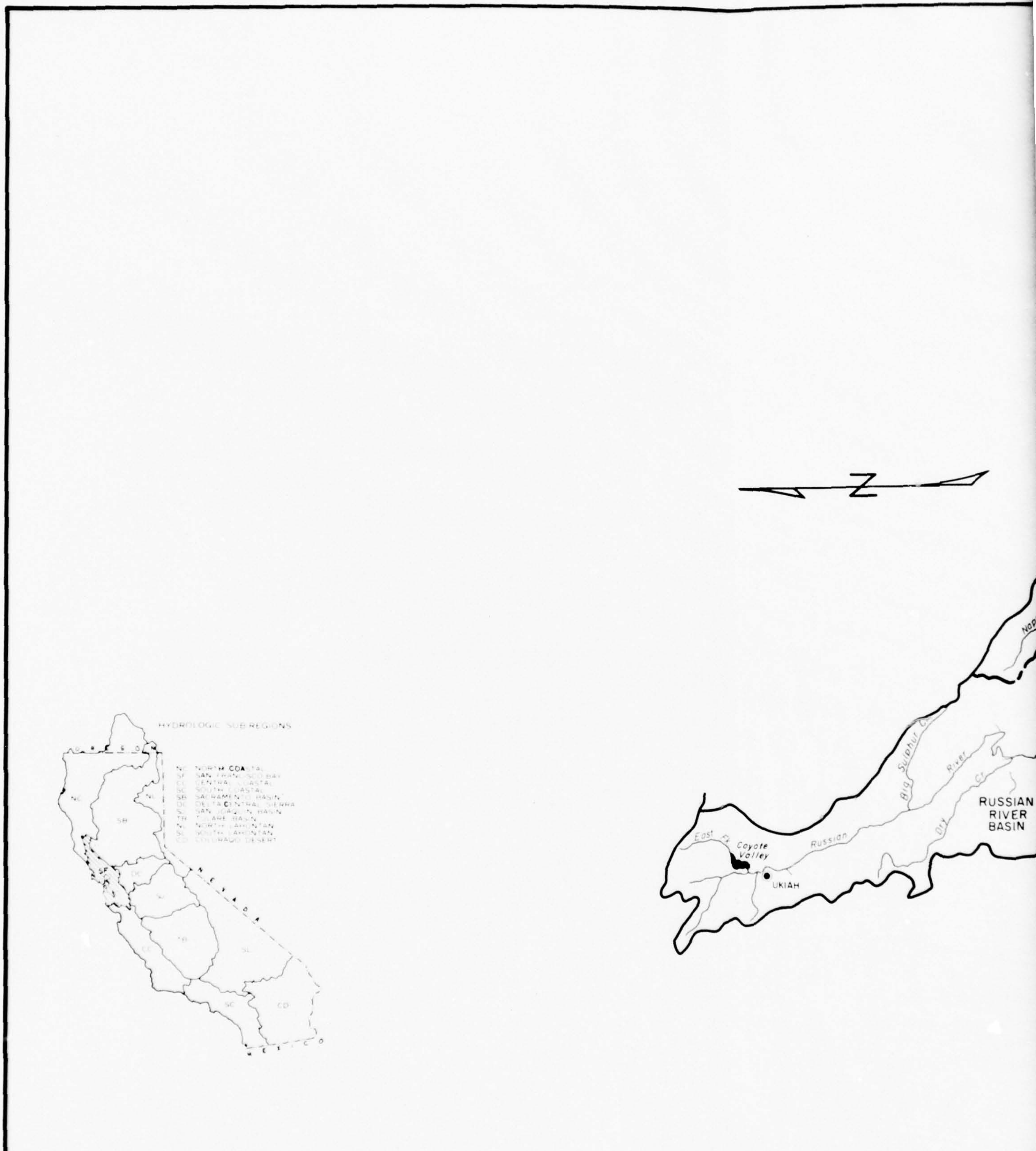
TABLE 11

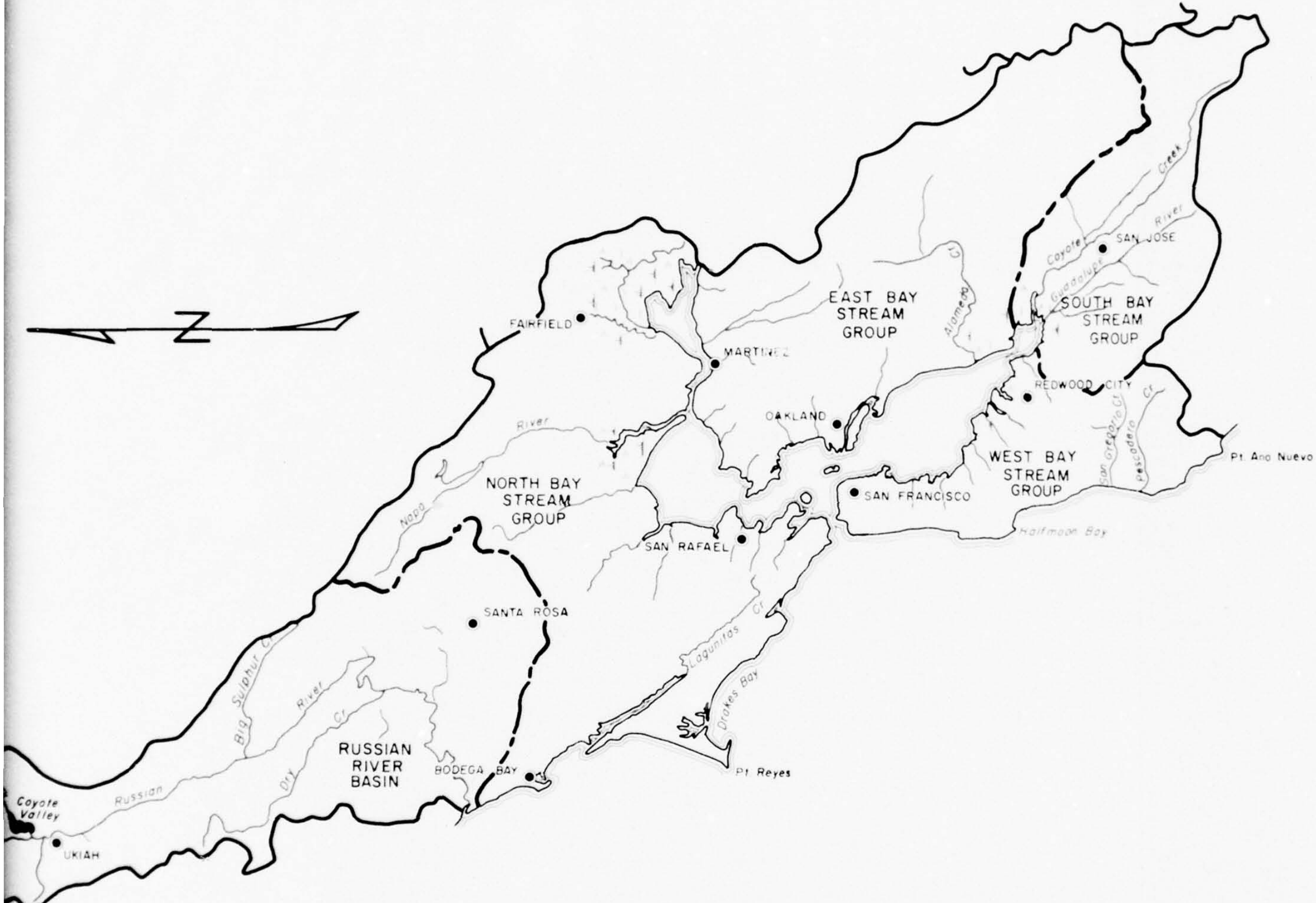
SAN FRANCISCO BAY SUBREGION OF THE CALIFORNIA REGION

Flow Data at Selected Locations
(Flows in 1,000 cfs)

Study area/ stream	Location	Non-damaging flow 1/	Date	Maximum flood of record					Flow of standard project flood				Flow of 100-year frequency flood			
				Flow												
				At time of occurrence	Existing (1965) project conditions	Future project conditions 2/			Existing (1965) project conditions	Future project conditions 2/			Existing (1965) project conditions	Future project conditions 2/		
						1980	2000	2020		1980	2000	2020		1980	2000	2020
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Russian River Basin																
Russian River	Guerneville	34	Dec64	93	93	77	66	61	146	118	103	96	122	101	89	84
East Bay Stream Group																
Alameda Creek	Niles	12	Dec55	29	29	22	22	22	70	51	51	51	43	33	33	33
West Bay Stream Group																
Pescadero Creek	Pescadero Road	3	Dec55	10	10	7	7	7	20	16	16	16	17	12	12	12

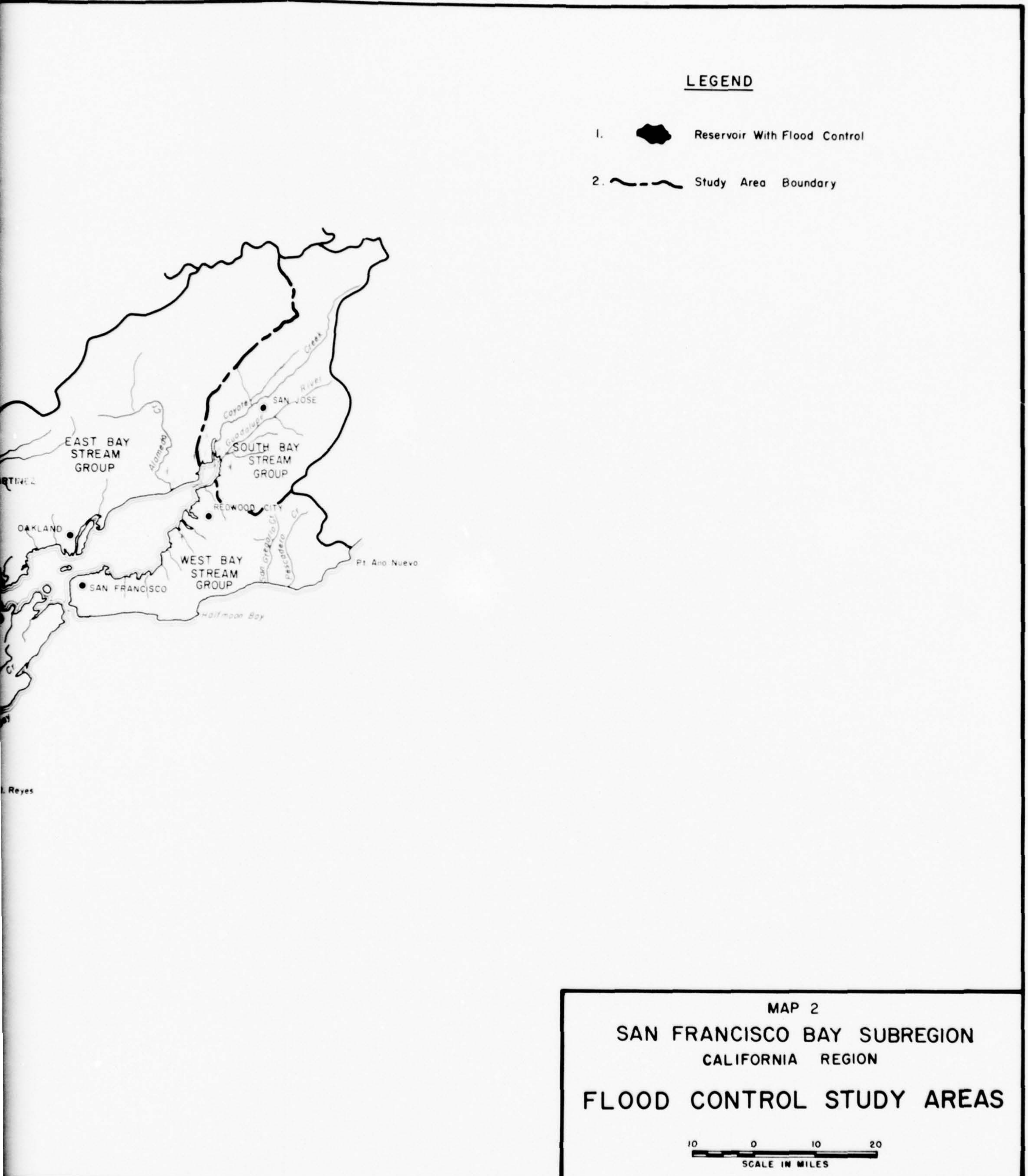
1/ Under 1965 project conditions.
2/ Flows as modified by projects likely to be in a future flood control program by the years 1980, 2000, and 2020.


HYDROLOGIC SUB-REGIONS
NC NORTH COASTAL
SF SAN FRANCISCO BAY
CC CENTRAL COASTAL
SC SOUTH COASTAL
SB SACRAMENTO BASIN
DC DELTA CENTRAL SIERRA
SJ SAN JOAQUIN BASIN
TB TULARE BASIN
NL NORTH LAHONTAN
SL SOUTH LAHONTAN
CD COLORADO DESERT
OREGON
NEVADA
MEXICO
N
Napa
Big Sulphur Cr.
River
Dry Cr.
RUSSIAN RIVER BASIN
East Fk.
Coyote Valley
Russian
UKIAH



N
EAST BAY
STREAM
GROUP
SOUTH BAY
STREAM
GROUP
WEST BAY
STREAM
GROUP
NORTH BAY
STREAM
GROUP
RUSSIAN
RIVER
BASIN
FAIRFIELD
MARTINEZ
OAKLAND
SAN JOSE
REDWOOD CITY
SAN FRANCISCO
SAN RAFAEL
SANTA ROSA
BODEGA BAY
UKIAH
Coyote Valley
Pt. Reyes
Pt. Ano Nuevo
Halfmoon Bay
Drakes Bay
Lagunitas Cr.
Napa
River
Russian
River
Big Sulphur Cr.
Dry Cr.
Alameda Cr.
Coyote Creek
Guadalupe River
San Gregorio Cr.
Pescadero Cr.

2



MAP 2
SAN FRANCISCO BAY SUBREGION
CALIFORNIA REGION
FLOOD CONTROL STUDY AREAS

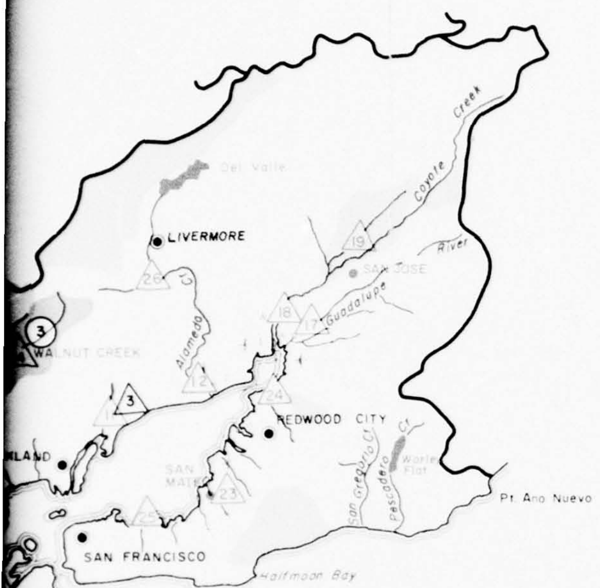

N
East Fk
Coyote Valley
Redwood Valley
UKIAH
Russian
Dry
Feliz
McDowell
15
Big Sulphur Cr.
Little Sulphur
River
16
Cr.
Warm Springs
Knights Valley


HYDROLOGIC SUB-REGIONS
NC - NORTH COASTAL
SF - SAN FRANCISCO BAY
CC - CENTRAL COASTAL
SC - SOUTH COASTAL
SB - SACRAMENTO BASIN
DC - DELTA-CENTRAL SIERRA
SJ - SAN JOAQUIN BASIN
TB - TULARE BASIN
NL - NORTH LAHONTAN
SL - SOUTH LAHONTAN
CD - COLORADO DESERT
NC
SB
NL
DC
SJ
TB
CC
SL
SC
CD

FAIRFIELD
MARTINEZ
WALNUT CREEK
LIVERMORE
Del Valle
Coyote Creek
River
Guadalupe
Alameda Cr.
OAKLAND
REDWOOD CITY
San Gregorio Cr.
Pescadero Cr.
Pt. Ano Nuevo
SAN FRANCISCO
Halfmoon Bay
Napa
River
SONOMA
SAN RAFAEL
SANTA ROSA
Knights Valley
Mark West
Lagunitas Cr.
Drakes Bay
Big Sulphur Cr.
River
Cr.
Mill Creek
BODEGA BAY
Pt. Reyes
Russian
Dry
Warm Springs

1. Exis

2. Po



LEGEND

1. Existing Project (in Operation 1965)

Reservoirs With Flood Control
1. Coyote Valley

Levee & Channel Projects
1. Coyote Cr. (Marin Co)
2. Rheem Cr.
3. San Lorenzo Cr.

Watershed Projects
1. Central Sonoma Area
2. Napa R.
3. Walnut Creek

2. Potential Future Flood Control Program
A(1966–1980), A_1(Constructed or Funded for Construction as of FY'1970), B(1981–2000), C(2001–2020),(See Tables 6 & 7)

Reservoirs with Flood Control

1. Warm Springs (A_1)
2. Knights Valley (A)
3. Del Valle (A_1)
4. Worley Flat (A)
5. Redwood Valley (B)
6. Little Sulphur (B)
7. Mill Creek (B)
8. Mark West (B)
9. Robinson (C)
10. Feliz (C)
11. Mc Dowell (C)

Levee & Channel Projects

1. Sonoma Cr. (A)
2. Napa R. (A)
3. Novato Cr. (A)
4. Corte Madera Cr. (A_1)
5. Arroyo Corte Madera Del Persidio (A)
6. Wildcat-San Pablo Crs.(A)
7. Alhambra Cr.(A)
8. Fairfield Strms (A)
9. Rodeo Cr. (A_1)
10. Pinole Cr. (A_1)
11. San Leandro Cr. (A)
12. Alameda Cr. (A_1)
13. Walnut Cr. (A_1)
14. Walnut Cr. (A)
15. Russian R. (A_1)
16. Dry Cr. (A_1)
17. Guadalupe R. (A)
18. Coyote Cr. (Santa Clara Co.)(A)
19. Silver Cr. & Vicinity (A)
20. Pine Cr. Streams (A)
21. Petaluma R. (B)
22. San Rafael Cr.(B)
23. San Mateo Strms. (B)
24. San Francisquito Cr. (B)
25. Colma Cr. (B)
26. Alameda Cr. – Livermore (C)

Watershed Projects

Locations of Non-Structural Flood Plain Management Measures

MAP 3
SAN FRANCISCO BAY SUBREGION
CALIFORNIA REGION
FLOOD CONTROL PLAN

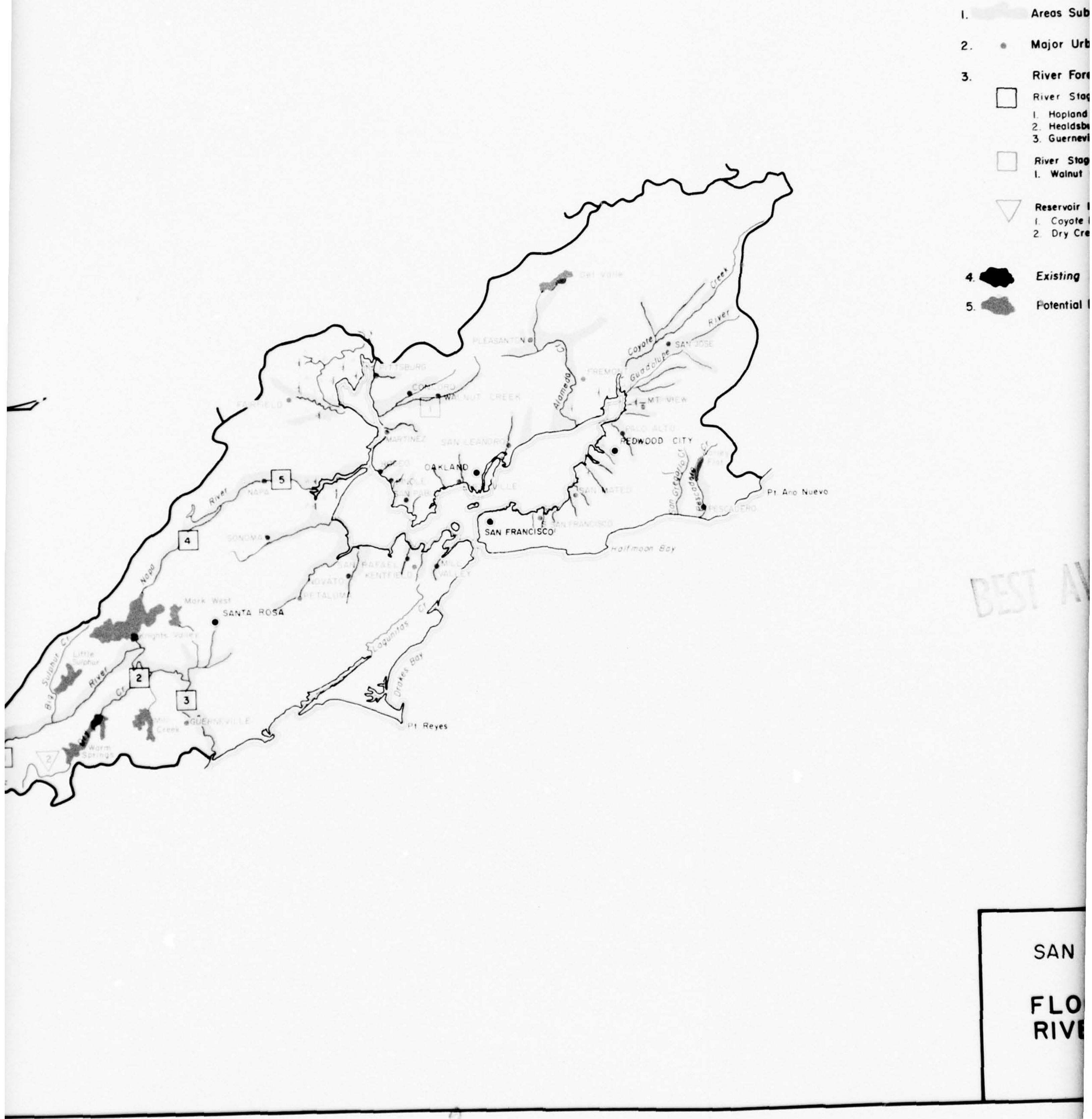
10 0 10 20
SCALE IN MILES

3

2


HYDROLOGIC SUB-REGIONS
NC - NORTH COASTAL
SF - SAN FRANCISCO BAY
CC - CENTRAL COASTAL
SC - SOUTH COASTAL
SB - SACRAMENTO BASIN
DC - DELTA CENTRAL SIERRA
SJ - SAN JOAQUIN BASIN
TB - TULARE BASIN
NL - NORTH LAHONTAN
SL - SOUTH LAHONTAN
CD - COLORADO DESERT
NC
SB
NL
DC
SJ
TB
SL
CC
SC
CD


N
East Fk
Coyote Valley
Redwood Valley
UKIAH
Robinson
McDowell
Russian
Feliz
Big Sulphur Cr
Little Sulphur



1. Areas Sub
2. Major Urb
3. River Fore
River Stag
1. Hopland
2. Healdsb
3. Guernevi
River Stag
1. Walnut
Reservoir
1. Coyote
2. Dry Cre
4. Existing
5. Potential
SAN
FLO
RIVE
PLEASANTON
SAN JOSE
PITTSBURG
CONCORD
WALNUT CREEK
FAIRFIELD
MARTINEZ
SAN LEANDRO
OAKLAND
NAPA
SONOMA
REDWOOD CITY
PALO ALTO
SAN MATEO
SAN FRANCISCO
Pt. Ano Nuevo
PESCADERO
Halfmoon Bay
SAN RAFAEL
NOVATO
KENTFIELD
MILL VALLEY
SANTA ROSA
Mark West
Knights Valley
GUERNEVILLE
Pt. Reyes
Drakes Bay
Lagunitas Cr.
Coyote Creek
Guadalupe River
Alameda Cr.
Napa River
Little Sulphur
Big Sulphur Cr.
Warm Springs
Mill Creek

LEGEND

1. Areas Subject to Flooding
2. Major Urban Damage Centers
3. River Forecasting Points

River Stage (Existing)
1. Hopland
2. Healdsburg
3. Guerneville Bridge
4. St. Helena
5. Napa

River Stage (Future)
1. Walnut Creek

Reservoir Inflow (Future)
1. Coyote Dam
2. Dry Creek Dam

4. Existing Reservoir With Flood Control
5. Potential Future Reservoir With Flood Control

MAP 4

SAN FRANCISCO BAY SUBREGION

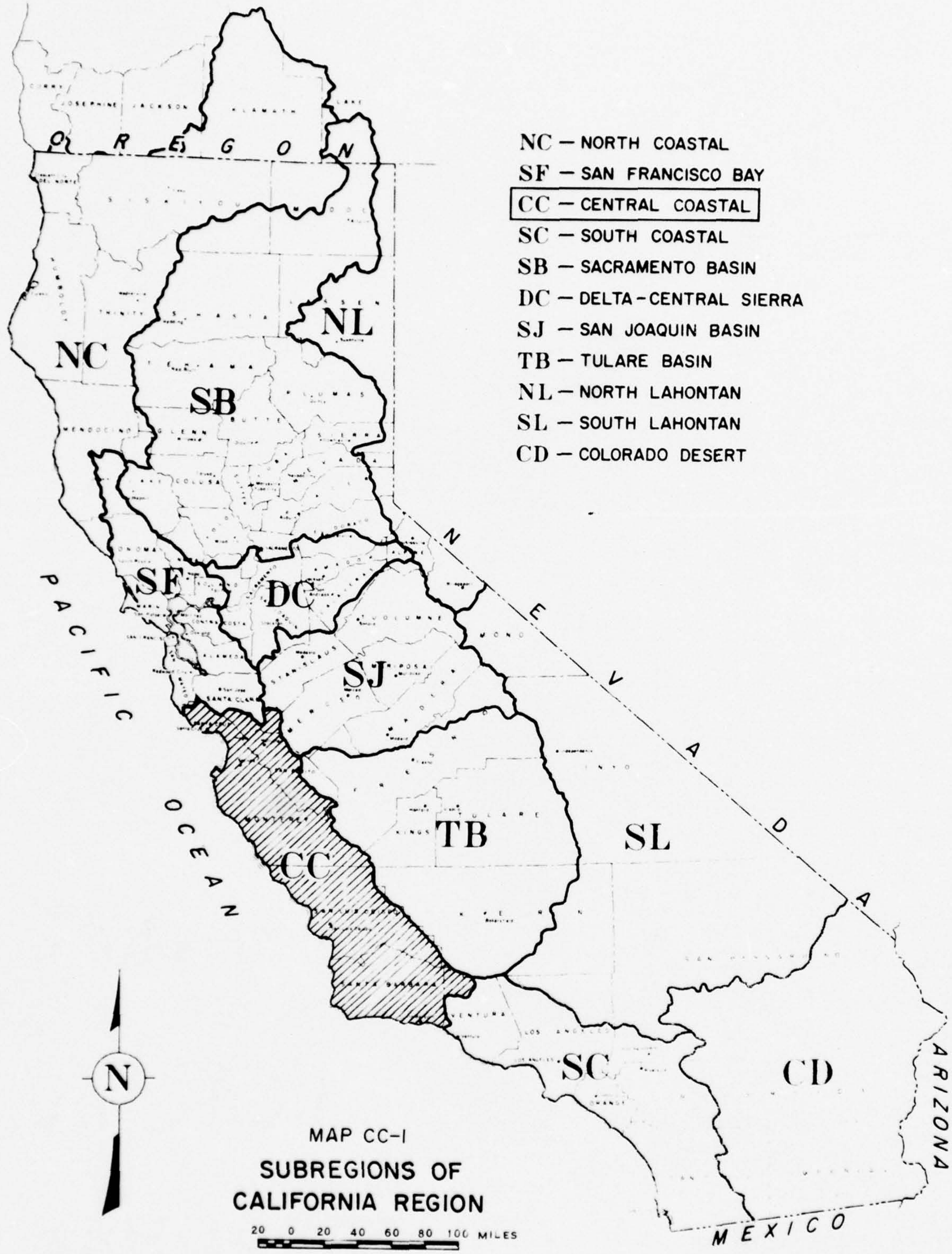
CALIFORNIA REGION

FLOOD DAMAGE AREAS AND RIVER FORECAST SERVICE

10 0 10 20

SCALE IN MILES

CENTRAL COASTAL SUBREGION



MAP CC-1
SUBREGIONS OF
CALIFORNIA REGION

CENTRAL COASTAL SUBREGION

General

The Central Coastal Subregion (CC) extends along the Pacific Ocean for approximately 350 miles, from Ano Nuevo Point in San Mateo County on the north to near the Santa Barbara-Ventura county line on the south. The subregion extends inland an average of about 50 miles to the crest of the coastal ranges and encompasses an area of 11,452 square miles. (See Map CC-1.) It is comprised of drainage areas of streams discharging into the Pacific Ocean and includes a closed basin in the southeastern part of the Salinas River Basin Study Area.

The climate of the subregion is temperate, with warm dry summers and mild wet winters. Local topography has marked effect on the direction of prevailing winds, frosts and amounts and areal distribution of rainfall. Temperatures along the coast range from a winter low of about 20 degrees to a summer high of nearly 100 degrees, with interior valleys having temperatures from below 10 degrees in the winter to well over 110 degrees in the summer. About 90 percent of the precipitation occurs during the months from November to April. Normal annual precipitation is around 21 inches, ranging from 17 inches for the Salinas River Basin, 20 inches for the Santa Ynez River Basin and 47 inches for the San Lorenzo River Basin and over 60 inches in the mountains southeast of Monterey.

The subregion had an estimated population of 687,000 in 1965. Major urban centers include Salinas, Monterey, Carmel, Santa Cruz, Watsonville, San Luis Obispo, Santa Maria and Santa Barbara. The economy of the subregion is supported primarily by agriculture and related industry. In addition, manufacturing, petroleum, mineral production and the recreation industry are contributors to the basic economy.

The basin is served by Federal, State and county roads, which afford ready access to all parts of the subregion. The subregion is also served by railways and several airlines.

Important streams include San Lorenzo, Pajaro, Salinas, Carmel, Santa Maria and Santa Ynez Rivers. The Salinas River is the largest stream in the subregion, draining over 40 percent of the total area. Its major tributaries include the Nacimiento River, San Antonio River and Arroyo Seco, originating west of the main stem in the Santa Lucia Range, and Estrella Creek and San Lorenzo Creek, originating east of the main stream in the Diablo Range. Additional information on the subregion can be found in Appendix II, The Region.

The Central Coastal Subregion has been subdivided into hydrologic study areas to facilitate investigation of present and future flood problems. These study areas are: Santa Cruz Stream Group; Pajaro River Basin; Salinas

River Basin; Carmel River Group; Morro-San Simeon Streams; San Luis Obispo-Arroyo Grande Streams; Santa Maria River Basin; Santa Ynez River Group; and Santa Barbara Streams. (See Map 2.)

History of Flooding

Although storms reaching the Central Coastal Subregion occur in considerable variations, certain characteristic conditions are conducive to flood producing rainfall over the area. In general, these storms occur with a southward displacement of the Aleutian Low and its associated frontal systems. The closer the center of the low to the California coast, the more severe the rainfall. Flood producing storms vary in duration from three days to six days. Storms lasting longer than three days generally result from a combination of weather patterns. Because of steep gradients, floods on streams in the subregion are characterized by extremely rapid rise and almost as rapid recession.

Recent major floods occurred in February-March 1938, January 1952, December 1955, April 1958, December 1966, January 1967, and January and February 1969. On a subregion basis, the 1938, 1955, and 1969 floods are the most significant and widespread, with the 1969 flood being the most severe of the three. Available records indicate 16 persons lost their lives to floods this century.

The floods of January and February 1969 were caused by a series of Pacific storms which brought widespread and severe damage to large areas in central and southern California, including nearly all of the study areas in the Central Coastal Subregion. Damage from the January and February 1969 floods totals approximately $61 million for the subregion, including nearly $34 million in the Salinas River Basin and $11 million in the Santa Ynez River Group. Flood fighting and cleanup costs for these two floods exceeded $2.5 million. Damages to agricultural and urban categories were about equally divided. Photo CC-I shows flooding conditions along the Salinas River near Spreckles during the February 1969 flood.

The 1955 flood inundated 14,400 acres in the northern portion of the subregion, resulting in $16 million in damages, of which 80 percent were agricultural, residential and commercial in nature.

The 1938 flood was extensive throughout the subregion. However, due to the low scale of development at the time, only about $1.2 million in damages were recorded. Damages from these and other significant floods in the subregion are tabulated on page CC-3 and are shown in more detail in Tables 1 and 2.

Flooding of the Salinas River near Spreckles during the flood of February 1969. (Corps of Engineers Photo.)

PHOTO CC-I

Flood season (year)	Forest & range resources & facilities	Agricultural & land	Residential & commercial	Industrial & utility	Public facilities	Total
	Flood damages 1/ - ($1,000)					
1937-38	18	737	51	153	205	1,164
1951-52	34	169	25	48	25	301
1955-56	2	3,545	9,389	540	2,606	16,082
1957-58	111	2,675	921	394	2,162	6,263
1966-67	76	4,110	715	1,350	1,490	7,741
1968-69	28	27,422	4,447	6,175	22,733	60,805

1/ Based on prices and project and economic conditions at time of occurrence of flood.

Estimated damages from a 100-year frequency flood for selected streams in the subregion are shown in Table 3. Peak flows of maximum floods of record, 100-year floods, and standard project floods for selected streams are shown in Table 11.

Present Status of Flood Control Improvements

The subregion has a moderate degree of flood protection on streams within the area. (See Map 3.) The existing flood damage reduction measures include flood forecasting, flood control storage and levee and channel improvements. The degree of protection provided by these measures varies from the 100-year or greater flood in urban areas, and from 10 to 50-year flood protection in agricultural areas.

The Federal-State River Forecast Center in Sacramento prepares river and flood forecasts which are disseminated through the San Francisco River District Office of the National Weather Service. These forecasts are for river stages during high water periods. The locations of forecasting points are shown on Map 4.

Existing (1965) flood control reservoirs are located in the Salinas River Basin and the Santa Maria River Basin. They provide a maximum storage of 289,000 acre-feet during the most critical flood situations. These reservoirs are:

Study area	Reservoir	Stream	Flood control capacity (ac.-ft.)	Drainage area (sq. miles)
Salinas River Basin	San Antonio	San Antonio River	50,000	324
	Nacimiento	Nacimiento River	150,000	324
Santa Maria River Basin	Twitchell	Cuyama River	89,000	1,135

Lake Cachuma on the Santa Ynez River and Lake Salinas on the upper Salinas River, both water supply reservoirs, also, contribute to flood damage reductions at times, especially when the reservoirs are not full at the beginning of flood runoff. The locations of these projects are shown on Map 3, with additional information given in Table 6.

Existing local protection works are composed of 69 miles of levees and 9 miles of improved channels. Of the 69 miles of levees, approximately 36 miles are located in the Pajaro River Basin and 24 miles in the Santa Maria River Basin. The only existing channel improvement projects providing better than 100-year flood protection are the San Lorenzo River Project completed in 1959 and the Santa Maria River Project completed in 1963. Existing (1965) levee and channel projects are listed in Table 7 and shown on Map 3.

The Arroyo Grande Watershed Project on Arroyo Grande Creek, installed prior to 1965, provides protection of the flood plain by channel improvement. The structural measures within this project are complemented by non-structural land treatment measures which retard runoff and reduce erosion.

The Flood Plain Management Services Program is explained in detail in the Regional Summary of this appendix. No flood plain information studies were conducted in the subregion prior to 1965. Three flood plain information reports have subsequently been published: one for the lower Carmel River in May 1967, and for two reaches of the Santa Ynez River in April 1969 and April 1970. Flood hazard information has been, and is being, provided to governmental agencies to permit them to proceed with such planning, engineering studies and other action as may be necessary for wise use of the flood plain.

In the Central Coastal Subregion, the accomplishments of existing flood control measures have been substantial. The existing system of reservoirs, levee and channel improvements, augmented by flood forecasting, has provided floodflow reduction and prevention of flood losses.

Under 1965 project and economic conditions, existing flood control developments would have prevented about $12.6 million in flood damages from the December 1955 flood and did prevent $2 million in damages during the 1966 flood and $6.4 million in the January-February 1969 floods. Nacimiento and San Antonio Reservoirs provided effective control of runoff on the Salinas River during the floods of December 1966 and January-February 1969. The two reservoirs prevented an estimated $2 million in flood damages during the December 1966 flood and $6.2 million during the February 1969 floods. Photo CC-II shows the Nacimiento Reservoir in operation during the flood of February 1969. The Twitchell Reservoir on the Cuyama River, together with the levee project on the Santa Maria River, prevented about $600,000 in flood damages during the January 1969 flood. The Arroyo Grande Watershed Project was effective in preventing about $1 million in flood damages for the same flood. Approximately $450,000 in actual flood losses were prevented by the existing levee project in the Pajaro River Basin during the December 1955 flood (1955 prices). Additional details are included in Table 2.

As is evident from an examination of the flood damage tables, significant problems exist within the subregion. These problems are particularly serious in the Pajaro River Basin, Salinas River Basin, Santa Barbara Streams study area and in the populated downstream sections of the various coastal streams such as the Santa Maria, Santa Ynez and Sisquoc Rivers.

Streambank erosion, which is a major problem in downstream channels such as those of the Salinas and Carmel Rivers, is not considered a serious problem in the tributary watershed areas. The subregion has a total of 9,700 miles of eroding streambank, of which 1,470 miles are considered serious. The primary erosion problem in the tributary areas is sediment production and deposition resulting from surface erosion. Present land treatment practices are primarily fire prevention and suppression, range seeding, critical area planting and crop residue utilization.

Average annual damages for the subregion are summarized as follows:

Study Area	Estimated Average Annual Damages ($1,000) 1/
Santa Cruz Stream Group	193
Pajaro River Basin	2,103
Salinas River Basin	3,613
Carmel River Group	685
Morro-San Simeon Streams	296
San Luis Obispo-Arroyo Grande Streams	270
Santa Maria River Basin	728
Santa Ynez River Group	604
Santa Barbara Streams	1,512
Total	10,004

1/ Based on 1965 prices, economic and project conditions.

Additional details are contained in Table 4 for the entire subregion and in Table 9 for urban areas. Major urban damage centers and areas subject to flooding are shown on Map 4.

Future Needs

The Central Coastal's future problems will stem largely from anticipated economic growth and change in the use of flood plains, thus requiring additional flood protection measures. It is estimated that the average annual flood damages in the Central Coastal Subregion (based on 1965 prices and economic conditions) exceed $10 million. The subregion's population is expected to increase from 687,000 in 1965 to 1,066,000 by 1980, 2,080,000 by 2000, and 4,063,000 by 2020 (base plan projections). Due to these factors, the average annual damages are expected to increase to about $14.7 million by 1980, $26.5 million by 2000, and $47.3 million by 2020 if additional reduction measures are not provided after 1965. Estimated damage data for existing and future conditions are contained in Tables 5 and 9a.

Measures Required to Satisfy Future Needs

Improved flood forecasting will become a necessary element in a comprehensive flood control program. A well-coordinated system of forecasting will permit more nearly optimum operation of projects for all purposes. Efforts will have to be made in developing procedures for flood forecasts in providing an adequate hydrologic data network and in expanding the area of coverage of river and flood forecasts. Future forecasting points are shown on Map 4. The required improvements to the flood forecasting system have been estimated to cost $180,000 for the period 1966-1980, $220,000 for 1981-2000, and $230,000 for 2001-2020.

Nacimiento Dam and Reservoir in operation during the February 1969 flood. This project was constructed by the Monterey County Water Conservation and Flood Control District in 1957. (Corps of Engineers Photo.)

PHOTO CC-11

Flood water storage will be important in the future flood control program. An additional 514,000 acre-feet of flood control capacity are required in the Central Coastal Subregion to satisfy future needs. The potential reservoirs and detention structures are contained in the following tabulation:

Study Area/ time frame in which needed	Reservoir	Stream	Flood Control Capacity (ac.-ft.)	Drainage Area (sq. miles)
Santa Cruz Stream Group				
1966-1980	Soquel	Soquel Creek	19,000	32
Pajaro River Basin				
1966-1980	Detention Structure	No Name	4,000	19
1981-2000	Gilroy	Carnadero Creek	23,000	64
	Detention Structures (7)	(Various)	6,000	59
2001-2020	Detention Structures (6)	(Various)	15,000	70
Salinas River Basin				
1966-1980	Detention Structures (3)	(Various)	4,000	48
1981-2000	Greenfield	Arroyo Seco	80,000	217
	Salinas	Salinas River	50,000	112
	Detention Structure	No Name	6,000	220
Carmel River Group				
1981-2000	Klondike Canyon	Carmel River	40,000	185
2001-2020	Detention Structures (8)	(Various)	29,000	155
Morro-San Simeon Streams				
1981-2000	Santa Rosa	Santa Rosa Creek	2,000	12
Santa Maria River Basin				
1966-1980	Detention Structures (5)	(Various)	1,000	2
1981-2000	Round Corral	Sisquoc River	108,000	280

Study Area/ time frame in which needed	Reservoir	Stream	Flood Control Capacity (ac.-ft.)	Drainage Area (sq. miles)
Santa Ynez Stream Group				
1966-1980	Lompoc	Santa Ynez River	125,000	790
	Detention Structures (2)	(Various)	1,000	3
Santa Barbara Streams				
1966-1980	Detention Structure	No Name	1,000	4
Total			514,000	

These reservoirs are shown on Map 3 and additional details are contained in Table 6. Estimated installation cost for the additional flood control capacity total $30.7 million for the period 1966-1980, $52.9 million for 1981-2000 and $13.5 million for 2001-2020.

Limited capacity of channels in various areas will require levee and channel work to safely pass floodflows. Preliminary studies indicate that additional levee and channel work is desirable in the following areas of the Central Coastal Subregion:

Study area/time frame in which needed	Levees (Bank Miles)	Channels (Miles)
Pajaro River Basin		
1966-1980	31	33
1981-2000	0	6
2001-2020	20	9
Salinas River Basin		
1966-1980	0	39
1981-2000	0	120
Morro-San Simeon Streams		
1981-2000	0	2
2001-2020	0	3

Study area/time frame in which needed	Levees (Bank Miles)	Channels (Miles)
San Luis Obispo-Arroyo Grande Streams		
1966-1980	0	2
1981-2000	0	3
2001-2020	0	1
Santa Maria River Basin		
1966-1980	0	2
1981-2000	0	4
2001-2020	0	2
Santa Ynez River Basin		
1966-1980	0	5
1981-2000	0	5
2001-2020	0	5
Santa Barbara Streams		
1966-1980	1	12
1981-2000	2	11
2001-2020	0	11
Total	54	275

Included in the above tabulation are the authorized modification of the existing Pajaro River Project, now in advance engineering and design stage, and the authorized, but inactive, bank stabilization and channel improvement project for the Salinas River. Also included are the authorized Upper and Lower Llagas Creek Watershed Projects which are now in the advance engineering and design stage. Locations of levee and channel work are indicated on Map 3 and additional details are included in Table 7.

Levee and channel work by local interests in the future is expected to be of limited scope and would probably not have significant influence in reducing the overall potential flood damage in the subregion. The estimated installation cost for additional levee and channel work totals $67.7 million for the period 1966-1980, $49.4 million for 1981-2000, and $26.4 million for 2001-2020.

The structural measures included in the preceeding tables are to be complemented by non-structural land treatment practices. The most frequently used present practices of critical area planting, rotation-defered grazing, range seeding and brush control are expected to be effective in the future. See Map 3 for potential watershed land treatment locations.

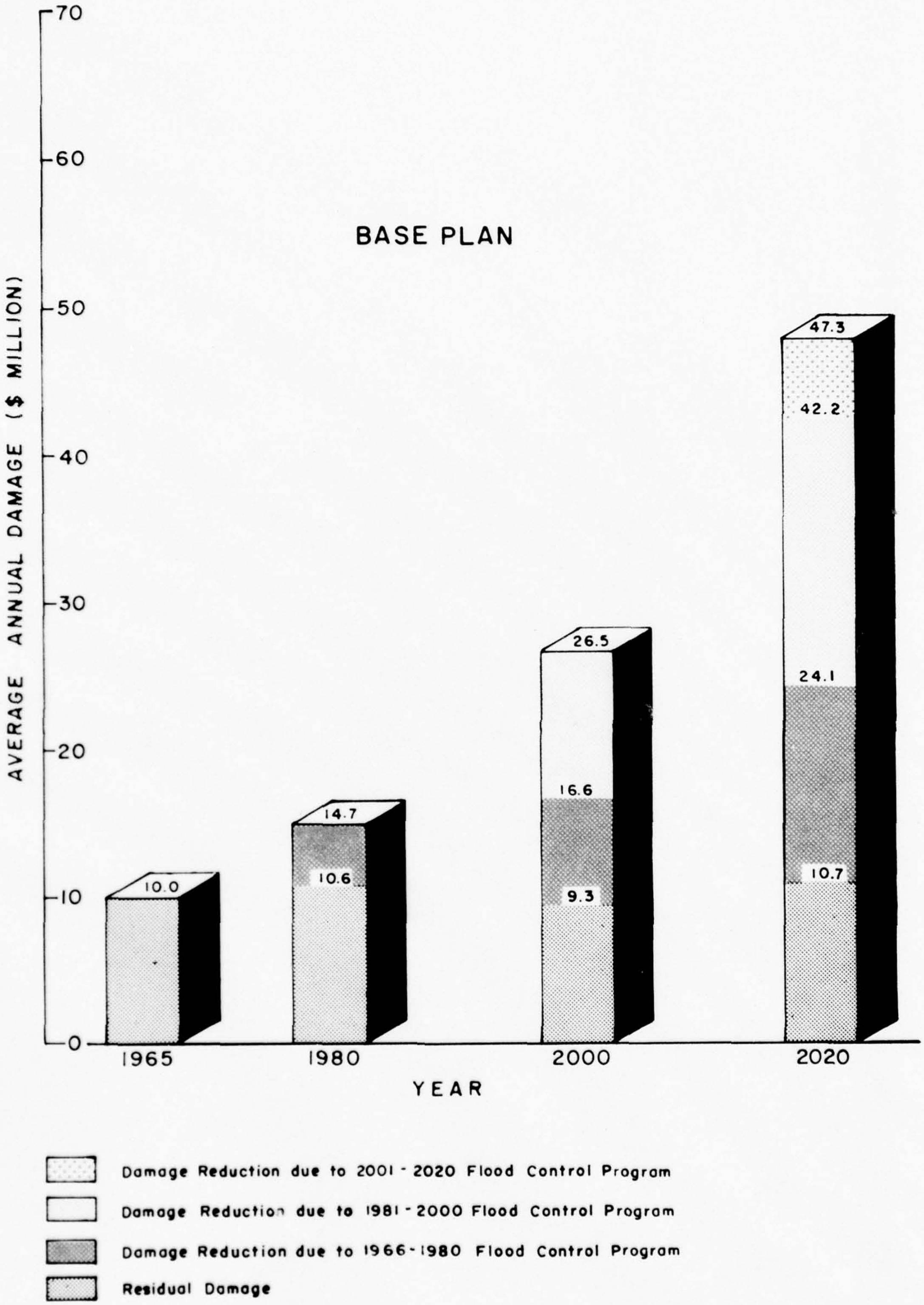
Estimated costs and acres of watershed land treatment measures are summarized below.

Land Treatment	1966-1980	1981-2000	2001-2020
Thousand acres	76	90	36
Thousand dollars	2,400	3,800	2,200

To combat existing and anticipated flood problems, emphasis on non-structural flood plain management measures will increase to become a more important component of the flood control program in the subregion. These measures will consist primarily of flood plain zoning and flood proofing. Particularly adaptable to such measures would be about 85 stream miles in the urban areas of the San Luis Obispo, Santa Maria and Santa Barbara stream groups. Table 9b lists damage reduction in urban areas attributable to future non-structural measures for the subregion. Non-structural flood plain management measures are discussed in the Regional Summary of this appendix. (Also see Table 8). The estimated costs for the above measures are \$8.0 million for the period 1966-1980, \$15.9 million for 1981-2000 and \$22.2 million for 2001-2020.

Potential to Satisfy Future Needs

The flood control program presented herein would reduce the projected average annual damages \$4.1 million by 1980, \$17.2 million by 2000 and \$36.6 million by 2020 at an estimated installation cost of \$109.0 million for the period 1966-1980, \$122.2 million for 1981-2000, and \$64.6 million for 2001-2020. Estimated annual OM&R costs for the 1966-1980, 1981-2000 and 2001-2020 portions of the flood control program are \$0.79 million, \$1.21 million and \$0.91 million (See Tables 10, 10a and 10b.) The effect of the potential flood control program on future damages is shown in Table 8 and graphically on Figure CC-1, and its effect on flood flows is shown in Table 11.



CALIFORNIA REGION
COMPREHENSIVE FRAMEWORK STUDY

PROJECTED AVERAGE ANNUAL FLOOD DAMAGES
(1965 PRICES AND PROJECT CONDITIONS-DATA FROM TABLES 5 & 8)

APPENDIX IX FIGURE CC-1

TABLE 1

CENTRAL COASTAL SUBREGION OF THE CALIFORNIA REGION

Historical Flood Data

Study area	Flood	Location/ flow (cfs)	Area inundated (1,000 acres)	Flood damages 1/ - ($1,000): Forest & range resources	Forest & range facilities	Crop & pasture	Other agricultural	Land	Residential & commercial	Industrial & utility	Public facilities	Total
1	2	3	4	5	6	7	8	9	10	11	12	13
Santa Cruz Stream Group		San Lorenzo River at Big Trees										
	Dec55	30,400	1.8	0	0	150	42	0	8,611	8	773	9,584
Pajaro River Basin		Chittenden										
	Dec55	24,000	12.6	2	0	1,468	979	906	778	532	1,833	6,498
	Apr58	23,500	19.2	2	0	870	760	973	713	394	2,136	5,848
Salinas River Basin		Bradley										
	Feb69	117,000	50.0	12	0	12,860	1,345	2,276	256	2,580	6,938	26,267
	Jan69	56,200	4.8	0	0	2,650	680	960	200	459	2,380	7,329
	Dec66	34,000	32.9	0	0	640	3,115	300	135	1,120	1,262	6,572
		Spreckles										
	Feb38	75,000	39.5	0	0	463	131	0	0	122	90	806
Carmel River Group		Robles del Rio										
	Jan-Feb69	7,400	0.6	0	16	0	70	326	304	16	270	1,002
	Apr58	7,100	1.3	0	109	55	15	2	208	0	26	415
Morro-San Simeon Streams		Santa Rosa Creek near Cambria										
	Jan69	3,400	N.A.	0	0	120	38	0	97	163	852	1,270
	Feb69	2,600	N.A.	0	0	40	13	0	42	51	324	470
San Luis Obispo - Arroyo Grande Streams		At Arroyo Grande										
	Jan69	3,600	N.A.	0	0	150	41	0	967	143	1,179	2,480
	Feb69	3,800	N.A.	0	0	49	17	0	14	39	261	380
	Jan52	5,370	N.A.	0	4	22	10	30	3	0	5	74
	Mar11	35,000	N.A.	-	-	-	-	-	-	-	-	45 3/
	Jan09	32,500	N.A.	-	-	-	-	-	-	-	-	43 3/
Santa Maria River Basin		At Guadalupe										
	Jan69	24,300	N.A.	0	0	150	88	0	21	9	112	380
	Feb69	27,200	N.A.	0	0	500	208	0			375	1,083
	Jan52	32,800	1,400	1	29	50	7	50	22	48	20	227
Santa Ynez River Group		Near Lompoc										
	Feb69	70,000	N.A.	0	0	702	109	0	180	685	1,103	2,779
	Jan69	100,000		0	0	1,877	251	0	611	1,655	3,903	8,297
	Mar38	45,000	4,300	3	15	60	40	43	51	31	115	358
	Jan14	64,000	N.A.	-	-	-	-	-	-	-	-	165 2/
	Jan07	79,000	N.A.	-	-	-	-	-	-	-	-	61 2/
Santa Barbara Streams		Atascadero Creek										
	Jan69	5,500	N.A.	0	0	1,902	0	0	1,755	375	5,036	9,068
	Jan67	5,000	N.A.	0	76	25	5	25	580	230	228	1,169

1/ Data based on prices and project and economic conditions at time of occurrence of flood.
2/ Details of total are not available. Most damages occurred to agricultural, highway and railroad property.
3/ Details of total are not available. All categories of agricultural, public and urban properties were damaged.
N.A. = Not available.

TABLE 2

CENTRAL COASTAL SUBREGION OF THE CALIFORNIA REGION

Flood Damage 1/

Study area	Flood	Location/ flow (cfs)	Total damages - ($1,000)					
			At time of flood 2/			1965 economic conditions & prices 3/		
			Actual damage	Damage without flood control projects	Damage prevented by flood control projects 4/	Damage with 1965 project conditions	Damage without flood control projects	Damage prevented by 1965 projects 5/
1	2	3	4	5	6	7	8	9
Santa Cruz Stream Group	Dec55	San Lorenzo River at Big Trees 30,400	9,584	9,584	0	3,040	14,900	11,860
Pajaro River Basin	Dec55	Chittenden 24,000	6,498	6,953	455	10,253	10,963	710
Salinas River Basin	Feb69	Bradley 117,000	26,267	32,467	6,200	22,700	27,900	5,200
Carmel River Group	Jan-Feb69	Robles del Rio 7,400	1,002	1,002	0	873	873	0
Morro - San Simeon Stream	Jan69	Santa Rosa Creek near Cambria 3,400	1,270	1,270	0	1,010	1,010	0
San Luis Obispo - Arroyo Grande Streams	Jan69	At Arroyo Grande 3,600	2,480	4,100	1,720	1,980	2,620	640
Santa Maria River Basin	Jan69	At Guadalupe 24,300	380	980	600	304	684	380
Santa Ynez River Group	Feb69	Near Lompoc 100,000	8,297	8,297	0	6,630	6,630	0
Santa Barbara Streams	Jan69	Atascadero Creek 5,500	9,068	9,068	0	7,250	7,250	0

1/ Maximum flood for which data are available.
2/ Data based on prices and project and economic conditions at time of occurrence of flood.
3/ Data based on recurrence of original flood.
4/ Column 6 = Col. 5 - Col. 4
5/ Column 9 = Col. 8 - Col. 7

TABLE 3

CENTRAL COASTAL SUBREGION OF THE CALIFORNIA REGION

Estimated Flood Damage for
the 100-Year Frequency Flood 1/
for Selected Streams

Study area/ stream	Area inundated (1,000 acres)	Flood damage 2/ - ($1,000) Forest & range resources	Forest & range facilities	Crop & pasture	Other agricultural	Land	Residential & commercial	Industrial & utilities	Public facilities	Total
1	2	3	4	5	6	7	8	9	10	11
Santa Cruz Stream Group										
Soquel Creek	0.1	0	0	31	8	42	2,022	0	682	2,785
Pajaro River Basin										
Pajaro River	51.5	4	0	4,074	1,647	1,111	5,078	1,038	3,152	16,104
Pacheco Creek	2.2	0	0	38	476	545	100	10	600	1,769
Santa Ana Creek	0.8	0	0	13	24	45	40	10	70	202
San Benito River	8.5	0	0	192	137	197	5	10	408	949
Salinas River Basin										
Salinas River	81.5	31	290	10,653	4,209	7,079	730	2,455	4,950	30,397
Arroyo Seco River	3.5	0	149	105	30	0	195	0	111	590
San Antonio River	-	0	38	0	0	0	0	0	1,000	1,038
Nacimiento River	-	0	15	0	0	0	0	0	0	15
Estrella Stream	11.8	30	0	47	115	449	0	15	1,100	1,756
Soda Lake Group	-	0	23	0	0	9	0	0	0	32
Carmel River Group										
Carmel River	1.5	0	48	165	45	0	3,370	0	420	4,048
Big Sur River	-	0	171	0	0	2	0	0	0	173
Morro-San Simeon Streams	6.1	4	8	469	230	663	340	900	1,300	3,914
San Luis Obispo-Arroyo Grande Streams	4.8	6	14	571	83	80	1,314	549	485	3,102
Santa Maria River Basin	53.8	98	713	1,091	593	376	1,655	1,075	460	6,061
Santa Ynez River Group	21.9	8	308	1,762	759	79	1,469	851	1,892	7,128
Santa Barbara Streams	7.0	0	106	1,898	921	1,934	14,831	2,399	4,512	26,601

1/ See Table 11 for magnitude of 100-year flood at selected stations.
2/ Based on July 1965 prices, economic conditions, and project conditions.

TABLE 4

CENTRAL COASTAL SUBREGION OF THE CALIFORNIA REGION

Estimated Average Annual Flood Damage

Study area (principal stream)	Flood damage 1/ - ($1,000)								
	Forest & range resources	Forest & range facilities	Crop & pasture	Other agricultural	Land	Residential & commercial	Industrial & utilities	Public facilities	Study area totals
1	2	3	4	5	6	7	8	9	10
Santa Cruz Stream Group (San Lorenzo River)	0	0	8	1	5	137	0	42	193
Pajaro River Basin (Pajaro River)	1	0	420	434	645	240	54	309	2,103
Salinas River Basin (Salinas River)	6	59	969	927	926	52	184	490	3,613
Carmel River Group (Carmel River)	0	69	30	9	36	474	4	63	685
Morro-San Simeon Streams (Morro Creek)	2	2	27	34	104	17	45	65	296
San Luis Obispo-Arroyo Grande Streams (Arroyo Grande Creek)	2	3	28	16	23	114	43	41	270
Santa Maria River Basin (Santa Maria River)	20	142	175	96	114	92	62	27	728
Santa Ynez River Group (Santa Ynez River)	2	63	118	65	14	107	73	162	604
Santa Barbara Streams (Mission Creek)	0	21	127	47	174	828	109	206	1,512
Total Central Coastal Subregion	33	359	1,902	1,629	2,041	2,061	574	1,405	10,004

1/ Damages based on July 1965 prices, economic conditions and project conditions.

Base Plan

TABLE 5

CENTRAL COASTAL SUBREGION OF THE CALIFORNIA REGION

Summary of Estimated Average Annual Flood Damage for Present and Future Conditions of Economic Development with Existing Flood Control Measures

Study area (principal stream)	Average annual flood damages 1/ - ($1,000)			
	1965 economic conditions 2/	1980 economic conditions	2000 economic conditions	2020 economic conditions
1	2	3	4	5
Santa Cruz Stream Group (San Lorenzo River)	193	421	992	2,028
Pajaro River Basin (Pajaro River)	2,103	2,763	4,784	8,716
Salinas River Basin (Salinas River)	3,613	4,416	6,592	11,012
Carmel River Group (Carmel River)	685	1,353	3,715	8,241
Morro-San Simeon Streams (Morro Creek)	296	470	880	1,730
San Luis Obispo - Arroyo Grande Streams (Arroyo Grande Creek)	270	480	995	2,100
Santa Maria River Basin (Santa Maria River)	728	1,107	1,640	2,634
Santa Ynez River Basin (Santa Ynez River)	604	1,018	1,807	3,301
Santa Barbara Streams (Mission Creek)	1,512	2,731	5,101	7,504
Total Central Coastal Subregion	10,004	14,759	26,506	47,266

1/ Damages based on July 1965 prices and project conditions and estimated economic conditions for the year shown.
2/ Figures in Column 2 are from Column 10 of Table 4.

TABLE 6

CENTRAL COASTAL SUBREGION OF THE CALIFORNIA REGION

Summary of Flood Control Capacity for Existing and Future Reservoirs

Study area	Flood control capacity 1/ - (1,000 ac-ft)				
	Existing projects (1965)	Projects 1966-1980 2/	Projects 1981-2000 2/	Projects 2001-2020 2/	Total projects as of 2020
1	2	3	4	5	6
Santa Cruz Stream Group	0	19	0	0	19
Pajaro River Basin	0	4	29	15	48
Salinas River Basin	200	4	136		340
Carmel River Group	0	0	40	29	69
Morro-San Simeon Streams	0	0	2	0	2
San Luis Obispo - Arroyo Grande Streams	0	0	0	0	0
Santa Maria River Basin	89	1	108	0	198
Santa Ynez River Basin	0	126	0	0	126
Santa Barbara Streams	0	1	0	0	1
Total Central Coastal Subregion	289	155	315	44	803

1/ Maximum flood control capacity. Does not include surcharge storage.
2/ Includes only reservoirs controlling the 100-year flood, or better, at the damsite above urban areas and reservoirs controlling at least the 10-year flood at the damsite where only rural areas are to be protected.

TABLE 7

CENTRAL COASTAL SUBREGION OF THE CALIFORNIA REGION

Summary of Levee and Channel Flood Protection Projects
- Existing and Future -

Study area	Levee and channel projects									
	Existing projects (1965)		Projects 1966-1980 1/		Projects 1981-2000 1/		Projects 2001-2020 1/		Total project as of 2020	
	Levees (miles)	Channels (miles)	Levees (miles)	Channels (miles)	Levees (miles)	Channels (miles)	Levees (miles)	Channels (miles)	Levees (miles)	Channels (miles)
1	2	3	4	5	6	7	8	9	10	11
Santa Cruz Stream Group	3	4	0	0	0	0	0	0	3	4
Pajaro River Basin	36	0	31	33	0	6	20	9	87	48
Salinas River Basin	5	0	0	39	0	120	0	0	5	159
Carmel River Basin	1	0	0	0	0	0	0	0	1	0
Morro-San Simeon Streams	0	0	0	0	0	2	0	3	0	5
San Luis Obispo - Arroyo Grande Streams	0	3	0	2	0	3	0	1	0	9
Santa Maria River Basin	24	2	0	2	0	4	0	2	24	10
Santa Ynez River Basin	0	0	0	5	0	5	0	5	0	15
Santa Barbara Streams	0	0	1	12	2	11	0	11	3	34
Total Central Coastal Subregion	69	9	32	93	2	151	20	31	123	284

1/ Includes only projects giving 100-year protection, or better, to urban areas and at least 10-year flood protection to agricultural areas.

TABLE 8

CENTRAL COASTAL SUBREGION OF THE CALIFORNIA REGION

Estimated Average Annual Flood Damage and Damage Reduction
- Present and Future Economic Conditions -

Study area (principal stream)	Total damages - 1965 prices ($1,000)									
	1965 economic & project conditions 1/	1980 economic conditions			2000 economic conditions			2020 economic conditions		
		W/1965 project conditions 2/	Reduction in damages due to 1966-1980 flood control program 3/	Residual damage W/ 1966-1980 program 4/	W/1966-1980 program	Reduction in damages due to 1981-2000 flood control program 3/	Residual damage W/ 1981-2000 program 5/	W/1981-2000 program	Reduction in damages due to 2001-2020 flood control program 3/	Residual damage W/ 2001-2020 program 6/
1	2	3	4	5	6	7	8	9	10	11
Santa Cruz Stream Group (San Lorenzo River)	193	421	382	39	80	0	80	112	0	112
Pajaro River Basin (Pajaro River)	2,103	2,763	1,257	1,506	2,515	547	1,968	3,389	1,464	1,925
Salinas River Basin (Salinas River)	3,613	4,416	257	4,159	6,260	3,311	2,949	4,604	602	4,002
Carmel River Group (Carmel River)	685	1,353	0	1,353	3,715	3,115	600	1,255	1,054	201
Morro-San Simeon Streams (Morro Creek)	296	470	25	445	805	265	540	1,050	310	740
San Luis Obispo - Arroyo Grande Streams (Arroyo Grande Creek)	270	480	215	265	530	295	235	450	135	315
Santa Maria River Basin (Santa Maria River)	728	1,107	155	952	1,434	620	814	1,195	130	1,065
Santa Ynez River Basin (Santa Ynez River)	604	1,018	609	409	730	190	540	961	325	636
Santa Barbara Streams (Mission Creek)	1,512	2,731	1,236	1,495	3,079	1,534	1,545	2,730	1,035	1,695
Total Central Coastal Subregion	10,004	14,759	4,136	10,623	19,148	9,877	9,271	15,746	5,055	10,691

1/ Figures shown in Column 2 are from Column 10 of Table 4 and are also shown in Column 2 of Table 5.
2/ Figures in Column 3 are from Column 3 of Table 5.
3/ Includes structural and non-structural measures.
4/ Column 5 = Column 3 - Column 4.
5/ Column 8 = Column 6 - Column 7.
6/ Column 11 = Column 9 - Column 10.

June 1971

TABLE 9

CENTRAL COASTAL SUBREGION OF THE CALIFORNIA REGION

Estimated Average Annual Flood Damage for Urban
Areas with Significant Flood Problems

Study area/ stream	Damage center	Average annual flood damages ($1,000) 1/ Residential	Commercial	Industrial & utilities	Public facilities	Total
1	2	3	4	5	6	7
Santa Cruz Stream Group						
Soquel Creek	Soquel	27	69	0	33	129
San Lorenzo River	Santa Cruz Vicinity	25	16	0	9	50
Subtotal		52	85	0	42	179
Pajaro River Basin						
Pajaro River	Watsonville & Pajaro	44	66	11	101	222
	Gilroy	18	24	4	21	67
Subtotal		62	90	15	122	289
Carmel River Group						
Carmel River	Carmel Valley & Vicinity	407	10	0	52	469
San Luis Obispo - Arroyo Grande Streams						
San Luis Obispo Creek	San Luis Obispo	18	23	23	19	83
Arroyo Grande Creek	Arroyo Grande	49	10	12	15	86
Subtotal		67	33	35	34	169
Santa Maria River Basin						
Santa Maria River	Santa Maria	42	39	58	26	165
Santa Ynez River Basin						
Santa Ynez River	Lompoc	27	44	61	109	241
Santa Barbara Streams						
Mission Creek	Carpenteria	5	2	4	4	15
	Santa Barbara	377	56	34	70	537
	Goleta	78	87	51	84	300
Subtotal		460	145	89	158	852
Total Central Coastal Subregion		1,117	446	258	543	2,364

1/ Damages are based on July 1965 prices, economic conditions, and project conditions.

TABLE 9a

CENTRAL COASTAL SUBREGION OF THE CALIFORNIA REGION

Summary of Estimated Average Annual Flood Damage for Urban Areas with Significant Flood Problems
- Present and Future Conditions of Economic Development
with Existing Flood Control Measures -

Study area/ stream	Damage center	Average annual flood damages 1/ - ($1,000)			
		1965 economic conditions 2/	1980 economic conditions	2000 economic conditions	2020 economic conditions
1	2	3	4	5	6
Santa Cruz Stream Group	Soquel	129	271	771	1,731
	Santa Cruz Vicinity	50	109	204	276
Subtotal		179	380	975	2,007
Pajaro River Basin	Watsonville and Pajaro	222	434	1,150	2,550
	Gilroy	67	138	385	866
Subtotal		289	572	1,535	3,416
Carmel River Group	Carmel Valley and Vicinity	469	1,037	3,095	6,979
San Luis Obispo - Arroyo Grande Streams	San Luis Obispo	83	170	374	830
	Arroyo Grande	86	175	390	860
Subtotal		169	345	764	1,690
Santa Maria River Basin	Santa Maria	165	330	660	1,320
Santa Ynez River Basin	Lompoc	241	482	964	1,930
Santa Barbara Streams	Carpenteria	15	30	60	100
	Santa Barbara	537	1,070	2,140	3,200
	Goleta	300	600	1,200	1,800
Subtotal		852	1,700	3,400	5,100
Total Central Coastal Subregion		2,364	4,846	11,393	22,442

1/ Damages based on July 1965 prices and project conditions and estimated economic conditions for the year shown.
2/ Figures in Column 3 are from Column 7 of Table 9.

June 1971

TABLE 9b

CENTRAL COASTAL SUBREGION OF THE CALIFORNIA REGION

Estimated Average Annual Flood Damage and Damage Reduction
for Urban Areas with Significant Flood Problems
- Present and Future Economic Conditions -

Study area/ stream	Damage center	Total damages - 1965 prices ($1,000): 1965	1980 economic conditions				2000 economic conditions				2020 economic conditions			
		economic & project conditions 1/	W/1965 project conditions 2/	Reduction due to 1966-1980 program: Non-structural measures	Reduction due to 1966-1980 program: Structural measures	Residual damage w/1966-1980 program 3/	W/1966-1980 program	Reduction due to 1981-2000 program: Non-structural measures	Reduction due to 1981-2000 program: Structural measures	Residual damage w/1981-2000 program 4/	W/1981-2000 program	Reduction due to 2001-2020 program: Non-structural measures	Reduction due to 2001-2020 program: Structural measures	Residual damage w/2001-2020 program 5/
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Santa Cruz Stream Group														
Soquel Creek	Soquel	129	271	0	266	5	14	0	0	14	32	0	0	32
	Santa Cruz Vicinity	50	109	71	0	38	71	0	0	71	96	0	0	96
Subtotal		179	380	71	266	43	85	0	0	85	128	0	0	128
Pajaro River Group														
Pajaro River	Watsonville and Pajaro	222	434	0	425	9	24	0	0	24	53	0	0	53
	Gilroy	67	138	0	0	138	385	0	377	8	18	0	0	18
Subtotal		289	572	0	425	147	409	0	377	32	71	0	0	71
Carmel River Group														
Carmel River	Carmel Valley and Vicinity	469	1,037	0	0	1,037	3,095	0	3,033	62	140	0	0	140
San Luis Obispo - Arroyo Grande Streams														
San Luis Obispo Creek	San Luis Obispo	83	170	50	40	80	180	30	105	45	100	50	0	50
	Arroyo Grande	86	175	50	55	70	160	0	120	40	90	40	0	50
Subtotal		169	345	100	95	150	340	30	225	85	190	90	0	100
Santa Maria River Basin														
Santa Maria River	Santa Maria	165	330	25	90	215	450	90	240	120	270	10	90	170
Santa Ynez River Basin														
Santa Ynez River	Lompoc	241	482	0	385	97	200	50	50	100	200	0	150	50
Santa Barbara Streams														
Coastal Streams	Carpenteria	15	30	4	23	3	6	0	0	6	10	0	0	10
	Santa Barbara	537	1,070	100	0	970	1,940	110	1,100	730	1,100	40	800	260
	Goleta	300	600	40	400	160	320	120	0	200	300	75	0	225
Subtotal		852	1,700	144	423	1,133	2,266	230	1,100	936	1,410	115	800	495
Total Central Coastal Subregion		2,364	4,846	340	1,684	2,822	6,845	400	5,025	1,420	2,409	215	1,040	1,154

1/ Figures shown in Column 3 are from Column 7 of Table 9 and are also shown in Column 3 of Table 9a.
2/ San Francisco District portion only.
3/ Column 7 = Column 4 - Column 5 - Column 6.
4/ Column 11 = Column 8 - Column 9 - Column 10.
5/ Column 15 = Column 12 - Column 13 - Column 14.

TABLE 10

CENTRAL COASTAL SUBREGION OF THE CALIFORNIA REGION

Estimated Costs of Future Flood Control Program
- 1966 to 1980 -
($1,000)

Study area	Levees & channels: Federal: Installation costs	Levees & channels: Federal: Annual OM&R costs	Levees & channels: Non-Federal: Installation costs	Levees & channels: Non-Federal: Annual OM&R costs	Flood control reservoirs: Federal: Installation costs	Flood control reservoirs: Federal: Annual OM&R costs	Flood control reservoirs: Non-Federal: Installation costs	Flood control reservoirs: Non-Federal: Annual OM&R costs	Non-structural measures: Federal: Installation costs	Non-structural measures: Federal: Annual OM&R costs	Non-structural measures: Non-Federal: Installation costs	Non-structural measures: Non-Federal: Annual OM&R costs
1	2	3	4	5	6	7	8	9	10	11	12	13
Santa Cruz Stream Group	0	0	0	0	3,100	7	0	0	20	7	1,100	20
Pajaro River Basin	19,140	0	5,270	52	760	0	940	2	60	13	160	33
Salinas River Basin	11,400	0	5,620	75	2,550	0	2,500	10	590	70	530	76
Carmel River Group	0	0	0	0	0	0	0	0	60	8	90	13
Morro-San Simeon Streams	0	0	0	0	0	0	0	0	120	11	440	12
San Luis Obispo - Arroyo Grande Streams	2,000	0	500	8	0	0	0	0	100	7	1,760	15
Santa Maria River Basin	800	0	200	3	950	0	90	4	170	20	540	28
Santa Ynez River Group	4,000	0	1,000	15	14,630	0	4,860	50	370	37	470	23
Santa Barbara Streams	14,550	0	3,180	109	230	0	70	1	100	15	3,950	41
Total Central Coastal Subregion	51,890	0	15,770	262	22,220	7	8,460	67	1,590	188	9,040	261

TABLE 10a

CENTRAL COASTAL SUBREGION OF THE CALIFORNIA REGION

Estimated Costs of Future Flood Control Program
- 19[illegible] to 2000 -
($1,000)

Study area	Levees & channels: Federal: Installation costs	Levees & channels: Federal: Annual OM&R costs	Levees & channels: Non-Federal: Installation costs	Levees & channels: Non-Federal: Annual OM&R costs	Flood control reservoirs: Federal: Installation costs	Flood control reservoirs: Federal: Annual OM&R costs	Flood control reservoirs: Non-Federal: Installation costs	Flood control reservoirs: Non-Federal: Annual OM&R costs	Non-structural measures: Federal: Installation costs	Non-structural measures: Federal: Annual OM&R costs	Non-structural measures: Non-Federal: Installation costs	Non-structural measures: Non-Federal: Annual OM&R costs
1	2	3	4	5	6	7	8	9	10	11	12	13
Santa Cruz Stream Group	0	0	0	0	0	0	0	0	310	17	100	30
Pajaro River Basin	750	0	60	12	10,870	12	150	8	150	23	1,750	77
Salinas River Basin	14,100	0	2,500	100	15,590	30	220	3	510	125	6,570	210
Carmel River Group	0	0	0	0	9,400	15	0	0	70	14	160	25
Morro-San Simeon Streams	1,600	0	500	8	380	0	50	2	70	14	160	24
San Luis Obispo - Arroyo Grande Streams	3,500	0	1,000	14	0	0	0	0	50	11	910	18
Santa Maria River Basin	2,200	0	600	8	15,500	0	700	48	160	31	1,690	63
Santa Ynez River Group	4,000	0	1,000	15	0	0	0	0	170	59	1,560	53
Santa Barbara Streams	12,000	0	5,560	55	0	0	0	0	110	25	5,430	63
Total Central Coastal Subregion	38,150	0	11,240	212	51,740	57	1,120	61	1,600	319	18,330	563

TABLE 10b

CENTRAL COASTAL SUBREGION OF THE CALIFORNIA REGION

Estimated Costs of Future Flood Control Program
- 2001 to 2020 -
($1,000)

Study area	Levees & channels				Flood control reservoirs				Non-structural measures			
	Federal		Non-Federal		Federal		Non-Federal		Federal		Non-Federal	
	Installation costs	Annual OM&R costs	Installation costs	Annual OM&R costs	Installation costs	Annual OM&R costs	Installation costs	Annual OM&R costs	Installation costs	Annual OM&R costs	Installation costs	Annual OM&R costs
1	2	3	4	5	6	7	8	9	10	11	12	13
Santa Cruz Stream Group	0	0	0	0	0	0	0	0	40	24	70	33
Pajaro River Basin	8,550	0	1,240	26	6,430	0	1,490	21	90	33	6,230	90
Salinas River Basin	0	0	0	0	0	0	0	0	280	106	9,810	161
Carmel River Group	0	0	0	0	4,390	0	1,190	17	60	16	130	21
Morro-San Simeon Streams	2,000	0	700	10	0	0	0	0	40	4	1,860	19
San Luis Obispo - Arroyo Grande Streams	800	0	200	3	0	0	0	0	80	11	1,810	34
Santa Maria River Basin	800	0	200	3	0	0	0	0	120	44	360	41
Santa Ynez River Group	4,000	0	1,000	15	0	0	0	0	60	41	210	22
Santa Barbara Streams	4,500	0	2,400	20	0	0	0	0	90	37	3,340	59
Total Central Coastal Subregion	20,650	0	5,740	77	10,820	0	2,680	38	860	318	23,820	480

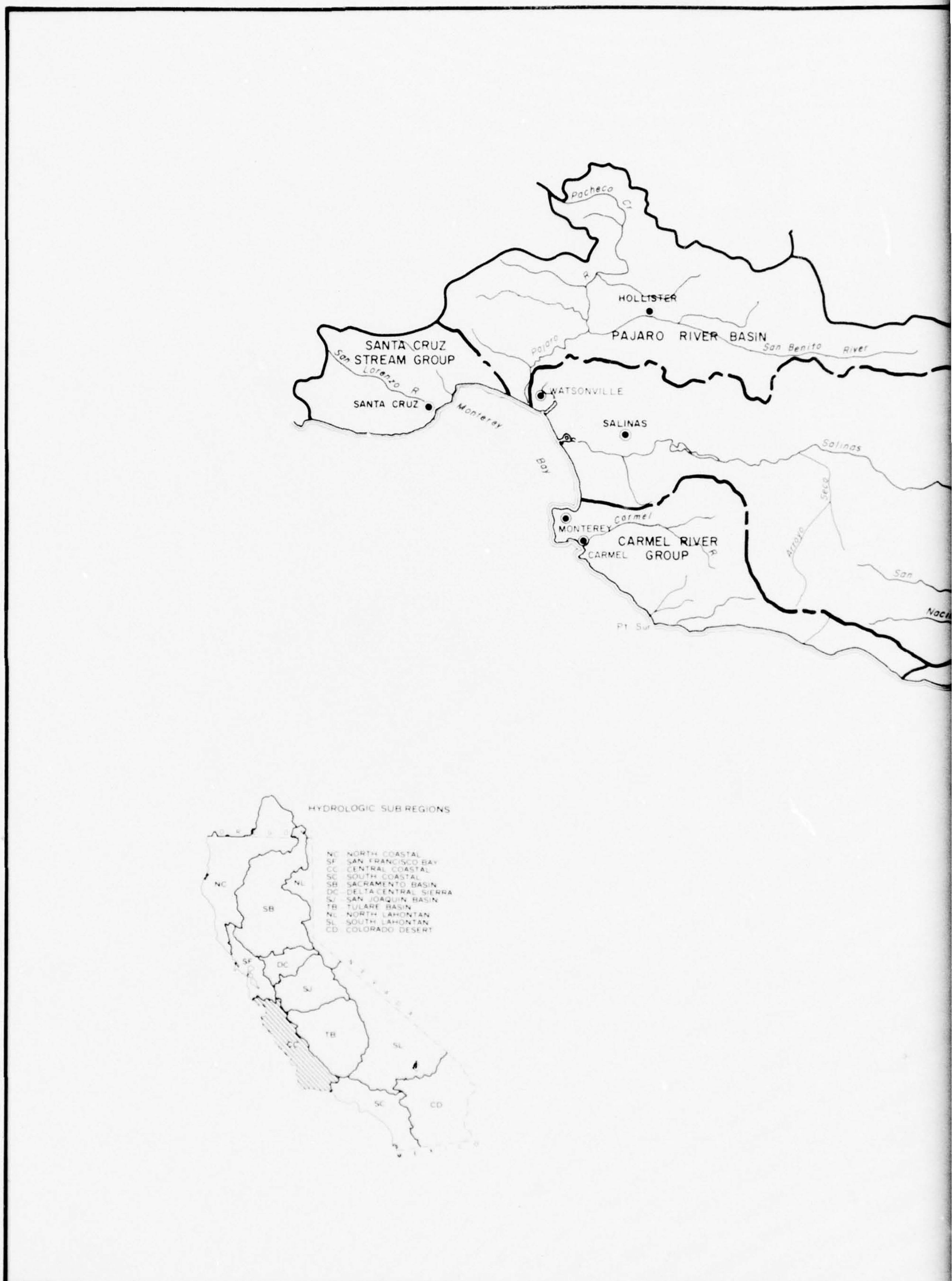
TABLE 11

CENTRAL COASTAL SUBREGION OF THE CALIFORNIA REGION

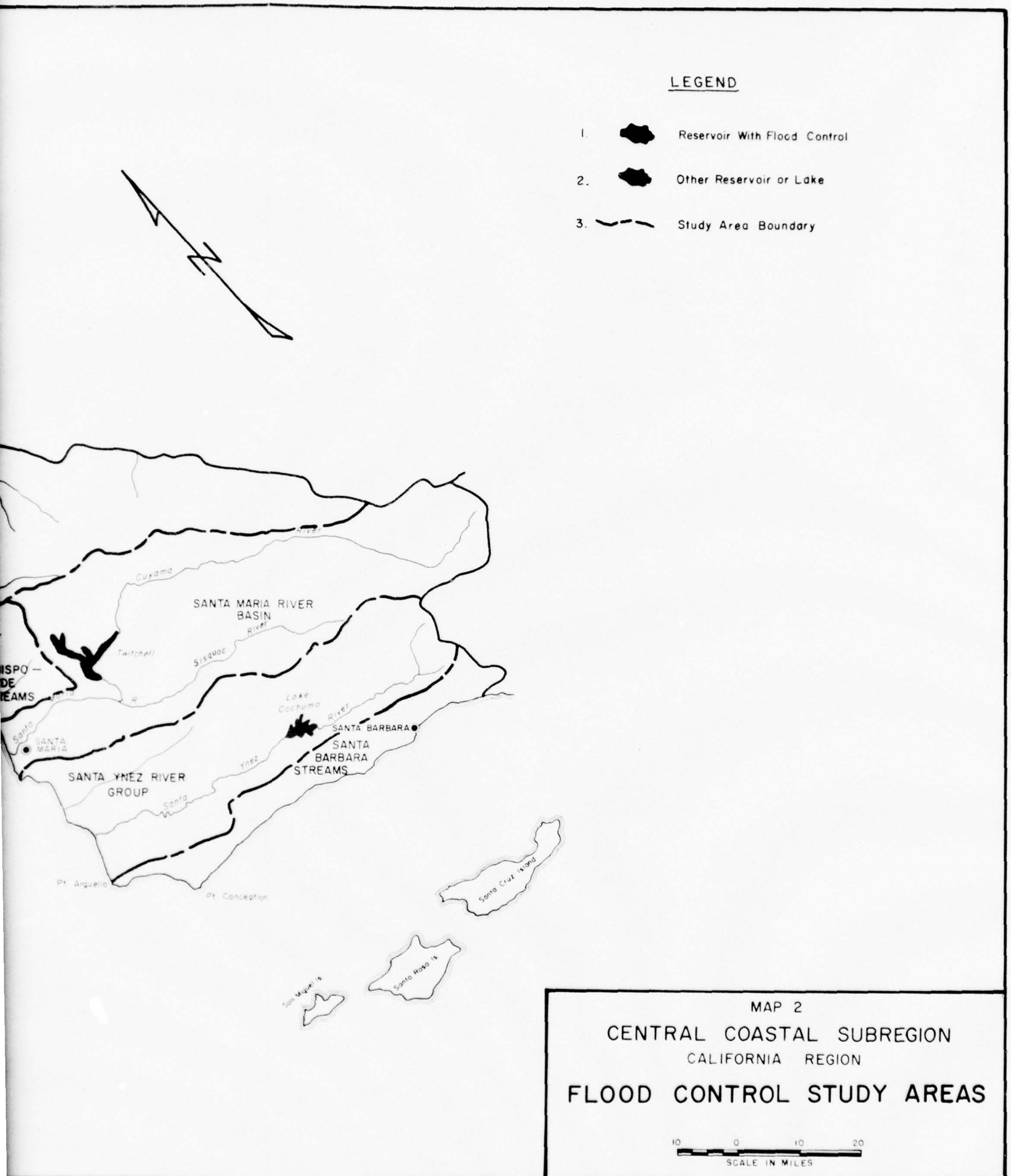
Flow Data at Selected Locations
(Flows in 1,000 cfs)

Study area/ stream	Location	Non-damaging flow 1/	Maximum flood of record						Flow of standard project flood				Flow of 100-year frequency flood			
			Date	Flow												
				At time of occurrence	Existing (1965) project conditions	Future project conditions 2/			Existing (1965) project conditions	Future project conditions 2/			Existing (1965) project conditions	Future project conditions 2/		
						1980	2000	2020		1980	2000	2020		1980	2000	2020
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Santa Cruz Stream Group																
Soquel Creek	Soquel	5	Dec55	12	12	3	3	3	20	5	5	5	17	4	4	4
Pajaro River Basin																
Pajaro River	Chittenden	19	Dec55	24	24	24	21	21	65	65	58	58	43	43	40	40
Salinas River Basin																
Salinas River	Bradley	20	Feb69	117	117	117	96	96	130	130	105	105	117	117	96	96
Carmel River Group																
Carmel River	Robles del Rio	4	Jan69	7	7	7	3	3	37	37	5	5	23	23	4	4
Morro-San Simeon Streams																
Santa Rosa Creek	Near Cambria	3	Jan69	3	3	3	1	1	21	21	3	3	15	15	2	2
Santa Maria River Basin																
Santa Maria River	At Guadalupe	160	Jan52	33	34	34	24	25	160	160	105	110	110	110	72	74
Sisquoc River	Near Sisquoc	NA	Jan69	21	21	12	13	14	72	40	42	43	50	28	29	30
Santa Ynez River Group																
Santa Ynez River	Near Lompoc	15	Jan07	120	126	15	15	15	130	15	15	16	110	12	12	13

1/ Under 1965 project conditions.
2/ Flows as modified by projects likely to be in a future flood control program by the years 1980, 2000, and 2020.


Pacheco Cr
HOLLISTER
PAJARO RIVER BASIN
San Benito River
Pajaro R
SANTA CRUZ
STREAM GROUP
San Lorenzo R
SANTA CRUZ
Monterey Bay
WATSONVILLE
SALINAS
Salinas
MONTEREY
Carmel R
CARMEL RIVER
GROUP
CARMEL
Arroyo Seco
Pt. Sur
HYDROLOGIC SUB REGIONS
NC NORTH COASTAL
SF SAN FRANCISCO BAY
CC CENTRAL COASTAL
SC SOUTH COASTAL
SB SACRAMENTO BASIN
DC DELTA CENTRAL SIERRA
SJ SAN JOAQUIN BASIN
TB TULARE BASIN
NL NORTH LAHONTAN
SL SOUTH LAHONTAN
CD COLORADO DESERT
NC
SB
NL
SF
DC
SJ
TB
SL
CC
SC
CD

SIN
San Benito River
Salinas
SALINAS RIVER BASIN
Arroyo Seco
River
Estrella
San Antonio R.
San Antonio
Nacimiento R
Nacimiento
River
Salinas
Cuyama
River
SANTA MARIA RIVER BASIN
MORRO - SAN SIMEON STREAMS
SAN LUIS OBISPO
Twitchell
Sisquoc River
SAN LUIS OBISPO - ARROYO GRANDE STREAMS
Morro Bay
R
Lake Cachuma
River
SANTA BARBARA
SANTA MARIA
SANTA BARBARA STREAMS
SANTA YNEZ RIVER GROUP
Ynez
Santa
Pt. Arguello
Pt. Conception
Santa Rosa Is.
San Miguel Is.



MAP 2

CENTRAL COASTAL SUBREGION

CALIFORNIA REGION

FLOOD CONTROL STUDY AREAS

3


Pacheco Cr
Gilroy
HOLLISTER
San Benito River
Soquel
San Lorenzo R
WATSONVILLE
Pajaro
SANTA CRUZ
Monterey Bay
SALINAS
Salinas
MONTEREY
Carmel R
CARMEL
Klondike Canyon
Arroyo Seco
Greenfield
San Antonio
Nacimiento
Pt. Sur
HYDROLOGIC SUB-REGIONS
NC NORTH COASTAL
SF SAN FRANCISCO BAY
CC CENTRAL COASTAL
SC SOUTH COASTAL
SB SACRAMENTO BASIN
DC DELTA-CENTRAL SIERRA
SJ SAN JOAQUIN BASIN
TB TULARE BASIN
NL NORTH LAHONTAN
SL SOUTH LAHONTAN
CD COLORADO DESERT
NC
SB
NL
SF
DC
SJ
TB
CC
SL
SC
CD


San Benito River
Salinas
Greenfield
ndike Canyon
Arroyo Seco
San Antonio
San Antonio
Nacimiento R
Nacimiento
Estrella River
River
Salinas
Santa Rosa
San Luis Obispo
Arroyo Grande
Morro Bay
Twitchell
Cuyama River
Sisquoc River
Santa Maria R
Round Corral
Santa Maria
Lake Cachuma
Santa Ynez River
Santa Barbara
Goleta
Lompoc
Lompoc
Pt. Arguello
Pt. Conception
San Miguel Is.
Santa Rosa Is.

LEGEND

1. Existing Projects (in Operation 1965)

Reservoirs With Flood Control
1. San Antonio
2. Nacimiento
3. Twitchell

Other Reservoir or Lake

Levee & Channel Projects
1. Pajaro R.
2. San Lorenzo R.
3. Santa Maria R.

Watershed Projects
1. Arroyo Grande Cr.

2. Potential Future Flood Control Program
A(1966-1980), B (1981-2000), C (2001-2020),
(See Tables 6 & 7)

Reservoirs
1. Soquel (A)
2. Lompoc (A)
3. Gilroy (B)
4. Greenfield (B)
5. Salinas (B)
6. Klondike Canyon (B)
7. Round Corral (B)
8. Santa Rosa (B)

Levee & Channel Projects
1. Pajaro R. (A)
2. Salinas R. (B)
3. Pajaro R. (C)
4. San Simeon Strms (C)
5. Morro Cr. (B)
6. San Luis Obispo (A)
7. San Luis Obispo (B)
8. Arroyo Grande (A)
9. Arroyo Grande (C)
10. Santa Maria Basin (A)
11. Santa Maria Basin (B)
12. Santa Maria Basin (C)
13. Santa Ynez Basin (A)
14. Santa Ynez Basin (B)
15. Santa Ynez Basin (C)
16. Santa Barbara Strms (A)
17. Santa Barbara Strms (B)
18. Santa Barbara Strms (C)

Watershed Projects

Locations of Non-Structural Flood Plain Management Measures

MAP 3

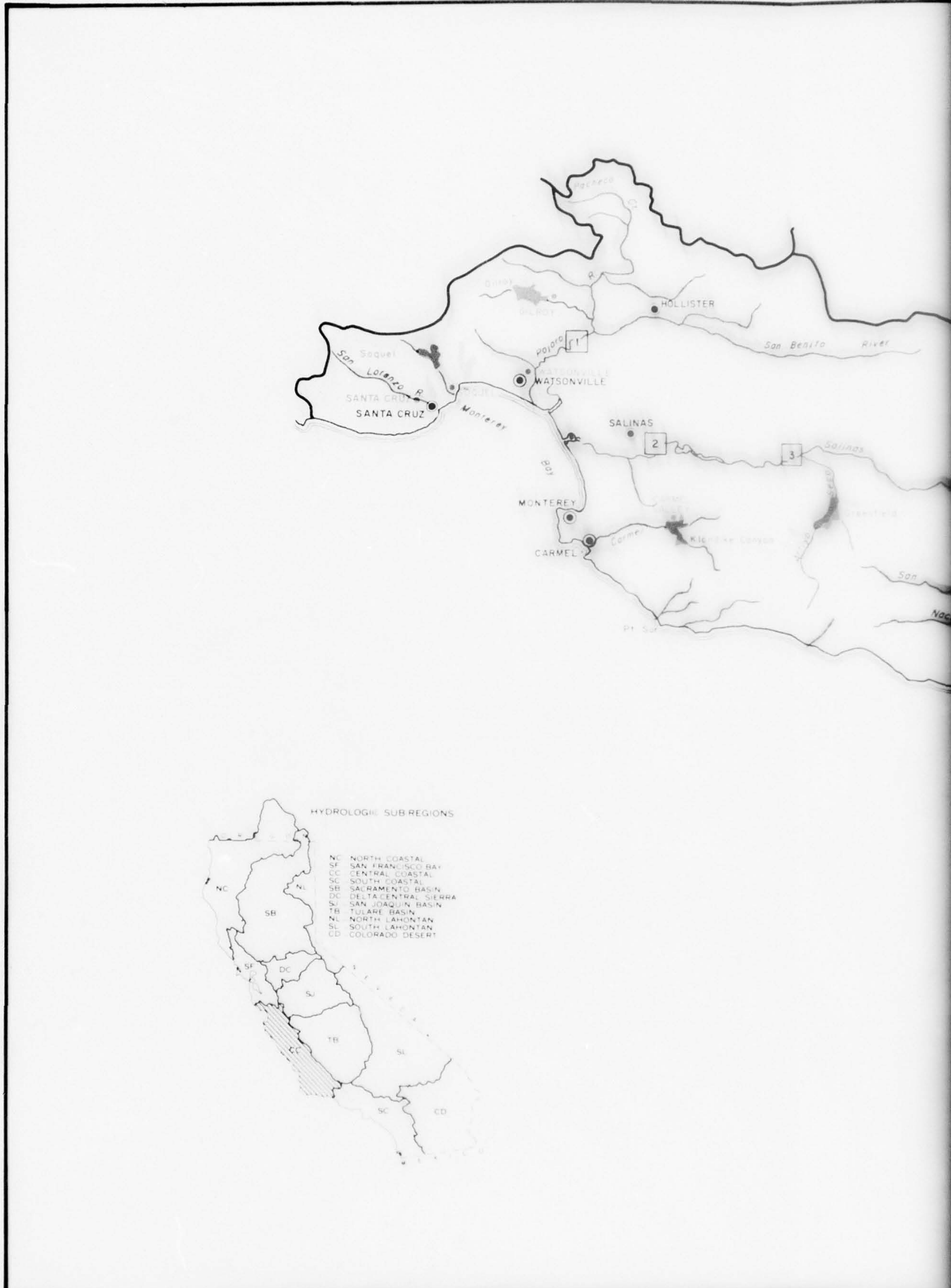
CENTRAL COASTAL SUBREGION

CALIFORNIA REGION

FLOOD CONTROL PLAN

10 0 10 20

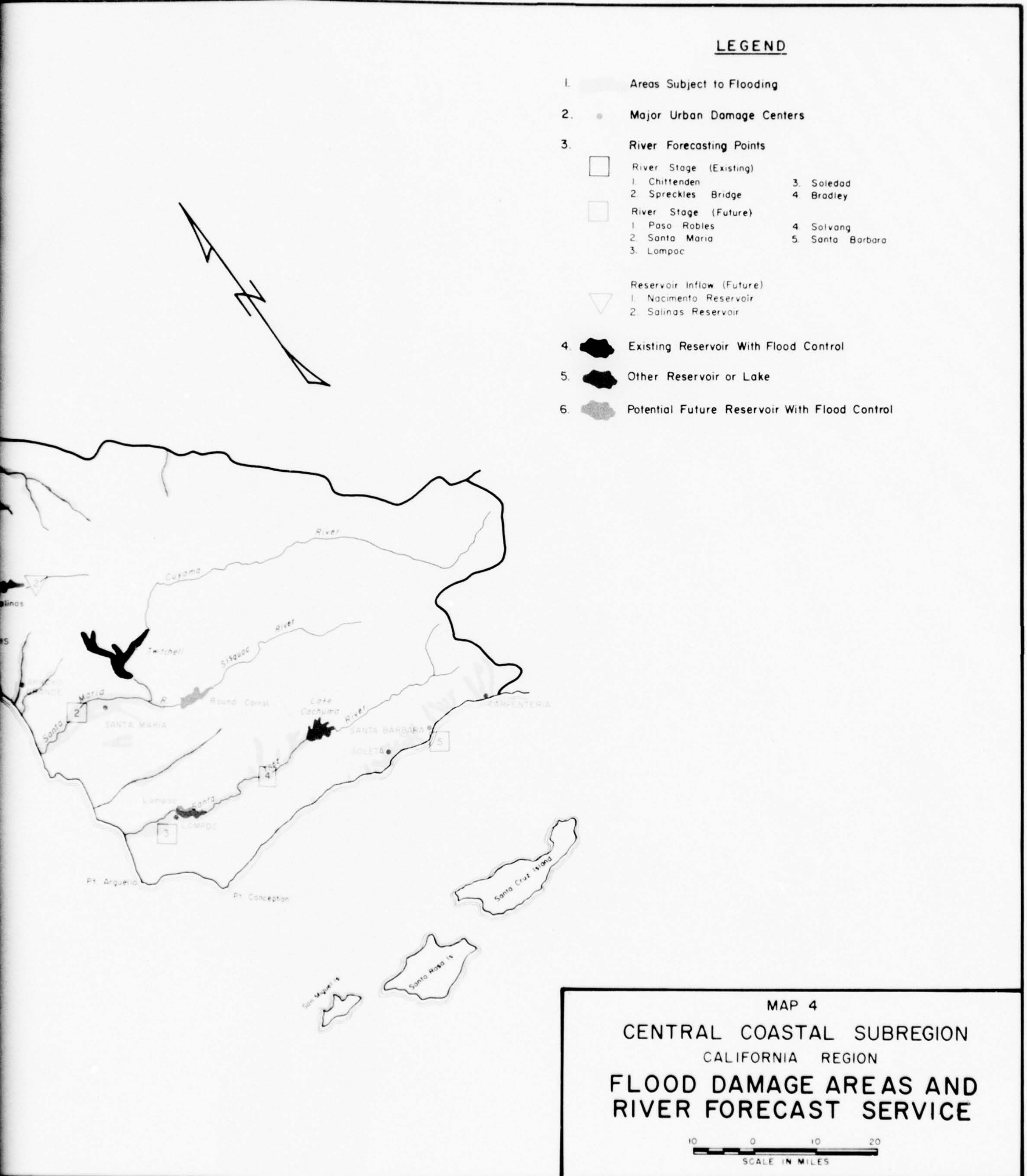
SCALE IN MILES



HOLLISTER
San Benito River
WATSONVILLE
SANTA CRUZ
San Lorenzo R.
Soquel
Monterey Bay
SALINAS
Salinas
MONTEREY
CARMEL
1
2
3
HYDROLOGIC SUB-REGIONS
NC NORTH COASTAL
SF SAN FRANCISCO BAY
CC CENTRAL COASTAL
SC SOUTH COASTAL
SB SACRAMENTO BASIN
DC DELTA-CENTRAL SIERRA
SJ SAN JOAQUIN BASIN
TB TULARE BASIN
NL NORTH LAHONTAN
SL SOUTH LAHONTAN
CD COLORADO DESERT

SALINAS RIVER BASIN
San Benito River
Salinas
Greenfield
San Antonio R.
San Antonio
Nacimiento R.
Nacimiento
Estrella River
River
Salinas
Santa Rosa
SAN LUIS OBISPO
Morro Bay
ARROYO GRANDE
Cuyama River
Twitchell
Sisquoc River
Santa Maria R.
SANTA MARIA
Round Corral
Lake Cachuma
Santa Ynez River
SANTA BARBARA
GOLETA
CARPENTERIA
LOMPOC
Pt. Arguello
Pt. Conception
Santa Cruz Island
Santa Rosa Is.
San Miguel Is.

2



MAP 4

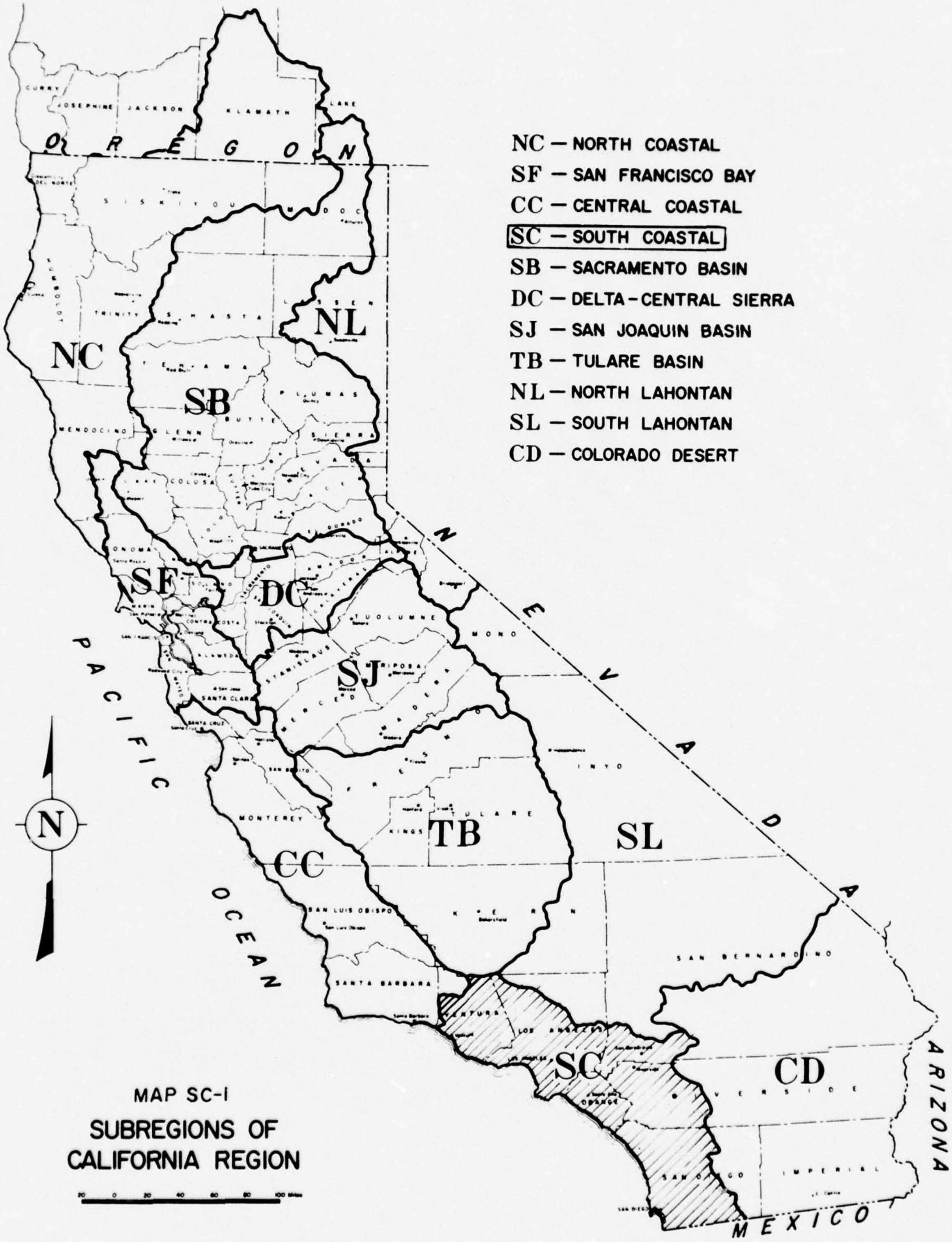
CENTRAL COASTAL SUBREGION

CALIFORNIA REGION

FLOOD DAMAGE AREAS AND RIVER FORECAST SERVICE

3

SOUTH COASTAL SUBREGION



MAP SC-1
SUBREGIONS OF CALIFORNIA REGION

SOUTH COASTAL SUBREGION

General

The South Coastal Subregion extends for about 200 miles along the Pacific Ocean from the Mexican border on the south to the northwestern boundary of the Ventura River Basin. The subregion, with a maximum width of 75 miles, has an area of 10,981 square miles and comprises the drainage areas of many coastal streams flowing into the Pacific Ocean.

The subregion rises from sea level to the peaks and ridges of the Tehachapi, San Gabriel, San Bernardino, and San Jacinto Mountains and the coastal ranges of San Diego County. The coastal plain, about 1/3 of the area of the subregion, slopes gently upward from sea level to an elevation between 500 and 800 feet at the base of the several mountains. On the plain, the contiguous drainage areas of adjacent streams are separated by low divides.

In general, the climate of the coastal basins of the South Coastal Subregion is mediterranean - a subtropical and semiarid climate. Temperatures are moderate, normally with small daily and annual ranges, and infrequent freezing on the coast. Temperatures in the mountains depend on altitude and topography, with below-freezing temperatures occurring at times during the winter. However, variations in climate are wide, ranging from arid desert-like conditions in the upper reaches of the Santa Ana drainage area to a mild and equable climate along the coast in San Diego County. Precipitation falls primarily from December to March, inclusive. It ranges from a mean seasonal minimum of about 10 inches on the coastal plain to as much as 45 inches in the mountains. Snow is common in the mountains but is rare in the interior valleys and on the coastal plain.

The South Coastal Subregion contains over one-half of the state's population in less than seven percent of the state's area. It had an estimated population of 9,910,000 in 1965. Important population centers are the Ventura-Oxnard area, the Los Angeles-Long Beach area, Orange County area, the San Bernardino-Riverside area, and San Diego County area. Because of its highly desirable climate and other favorable factors such as transportation and harbor facilities, the area has experienced a very intensive growth in population and industry. The areas economic activities are diverse. Major activities include agriculture, finance, mineral production, manufacturing, and foreign, retail and wholesale trade.

Transportation facilities in the subregion are well-developed and extensive. Highly developed Federal, State, and county roads, highways, and freeways afford ready access to all parts of the subregion except for some higher mountain areas. The road system also provides ready access to adjacent areas. Rail service is supplied by three transcontinental rail lines. There are several major airports serving transcontinental and overseas air lines, while a number of smaller airports connect with feeder and commuter air lines. Coastal harbors are developed for all craft from deep-draft ocean vessels to small recreation boats.

The subregion has been divided into study areas. These are delineated on Map 2 and listed in the several tables. Each study area includes the named major stream and also minor coastal streams flowing directly into the ocean. The study areas are: Ventura River Basin, Santa Clara River Basin, Calleguas Creek Basin, Malibu coastal streams, Santa Monica Bay coastal streams, Los Angeles River Basin, San Gabriel River Basin, Santa Ana River Basin, Orange County streams, Santa Margarita River Basin, San Luis Rey River Basin, San Dieguito River Basin, San Diego River Basin, Sweetwater River Basin, and the Otay-Tijuana Rivers Basin. Some 48 urban damage centers are affected by floodflows from one or more of these streams. Table 9 lists the communities and the study areas.

Additional information about the subregion can be found in Appendix II, "The Region".

History of Flooding

The area is subject to sudden and severe floods, with some flood damage occurring in most years. Most floods in the area are produced by general winter storms, usually occurring from December to March, inclusive. Snow is seldom a factor in flooding. Thunderstorms occur very infrequently along the coast and usually only during winter months, but are not uncommon in the higher mountains at any time. Thunderstorms cover comparatively small areas but may result in high-intensity precipitation for short durations, usually three hours or less. Flooding may occur from these storms.

Information about floods in the South Coastal streams begins in the diary record of the travels of the Spanish Mission Fathers between San Diego and San Francisco in 1769-70. Information on early floods is in the regional section of this appendix. These early records are not detailed enough to determine the magnitude of the early floods, nor are records of monetary damage available. However, these records are extensive enough to indicate that flood runoff in the many streams of the subregion has periodically submerged, damaged and washed away crops, residential, commercial and industrial developments, highways, railroads, bridges, and utility and public properties. And since 1914, 234 persons are known to have lost their lives from various floods.

The extensive flood of 1938 provided the first for which detailed damage and discharge records are available. It caused the loss of 87 lives and damage estimated at $78.6 million inundating 249,000 acres in the overflow areas of the streams from the Tijuana River in the south to the Ventura River in the north.

Large floods occurred in January and February 1969 resulting in the loss of 103 lives and extensive damage particularly in the north part of the subregion. The high stages on three streams during this period are

shown in Photos SC-I, SC-II and SC-III. In many areas the flood was the most severe of record. The damages amount to $157.4 million in the north part and $2.7 million in the south part of the subregion (San Diego County). Moderate and small floods have occurred frequently on several stream basins. A moderate flood causing some severe local damage occurred in 1943, while small local floods occurred in 1940, 1945, 1952, 1954, 1956, 1957, 1958, 1961, and 1965.

Emergency flood control activities, including flood fighting, rescue work, repair of existing flood control facilities, cleaning of streams and emergency bank protection, amounted to $559,000 through 1965. About $2,500,000 was expended on emergency restoration work to public facilities after the November-December 1965 floods. Damages from significant floods in the subregion are tabulated below and are shown in detail in Tables 1 and 2.

Flood of	Total damages	Acreage Inundated
1916	$10,981,000	96,500
1938	78,600,000	248,900
1965	5,005,000	5,000
1969	160,140,000	203,000

The damages shown are based on prices, and project and economic conditions at time of occurrence of the flood.

Peak flows of maximum floods of record, 100-year floods and standard project floods for selected stations in the subregion are shown in Table 11.

Present Status of Flood Control Improvements

An extensive flood control system has been developed in this subregion. Concentrated generally in three river basins--Los Angeles, San Gabriel and Santa Ana--its accomplishments have been substantial, functioning effectively to reduce flood damages. (See Map 3). The existing flood damage reduction measures, which provide flood protection to about three-quarters of the area subject to flooding, include flood forecasting, flood control storage, levees and channels, floodwater detention and debris control structures and watershed treatment. Part of the improvement provides protection to urban areas from discharges of 100-year or greater flood magnitudes, whereas most tributary stream improvements provide only 50-year protection or less. In agricultural areas improvements provide protection generally for 10 to 50-year magnitudes.

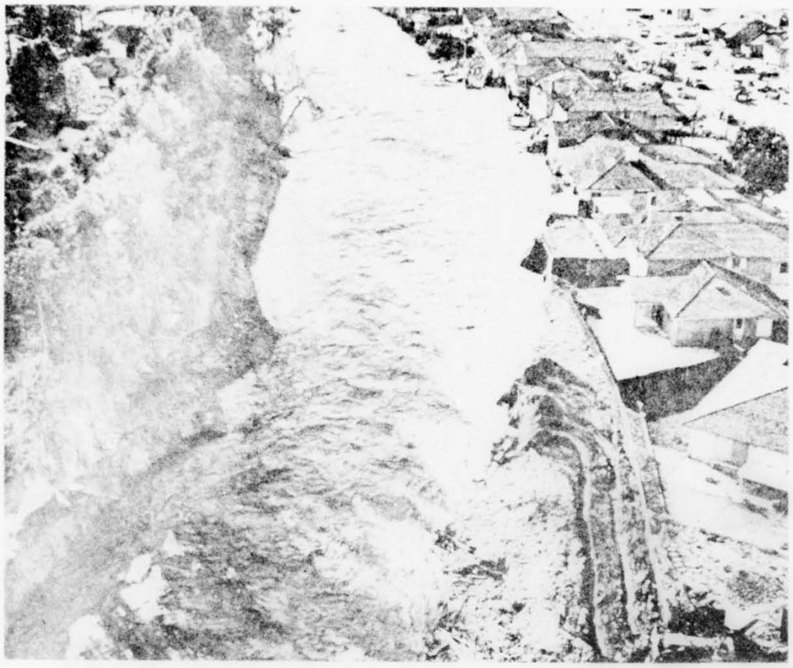
River and flood forecasting service is provided by the Federal-State River Forecast Center in Sacramento. Although no direct forecasts are prepared by the Center, advisory service is provided the county flood control

offices in developing flash flood forecast procedures for their use. The Los Angeles County Flood Control District provides river and flood forecasts for the county. Federal and State agencies and county flood control district personnel actively engage in emergency operation programs at the time of possible flood overflow. River and flood forecasting points are shown on Map 4.

Existing flood control reservoirs in the subregion supply a total of 438,000 acre-feet of storage. Reservoirs are listed in the following tabulation and shown on Map 3.

Study area	Reservoir	Stream	Flood control capacity (ac.-ft.)	Drainage area (sq. miles)
Los Angeles River Basin	Devils Gate	Arroyo Seco	2,700	32
	Big Tujunga #1	Big Tujunga Wash	4,100	82
	Hansen	Tujunga Wash	32,000	147
	Sepulveda	Los Angeles River	17,300	155
	Lopez	Pacoima Creek	200	34
San Gabriel River Basin	Puddingstone	Walnut Creek	17,200	32
	San Dimas	San Dimas Creek	1,000	16
	Cogswell	San Gabriel West Fork	10,700	39
	Santa Fe	San Gabriel River	33,400	231
	Whittier Narrows	San Gabriel River	36,200	554
	Brea	Brea Canyon Creek	4,100	23
	Carbon Canyon	Carbon Canyon Creek	7,000	19
	Fullerton	Fullerton Creek	700	5
Santa Ana River Basin	San Antonio	San Antonio Creek	9,300	27
	Prado	Santa Ana River	219,000	2,264
	Sycamore	Sycamore Creek	1,200	15
	Santiago	Santiago Creek	25,000	63
	Villa Park	Santiago Creek	15,600	83
San Luis Rey River Basin	Dixon	Escondido Creek	400	4

These projects are shown on Map 3. Hansen Reservoir is shown in Photo SC-IV.

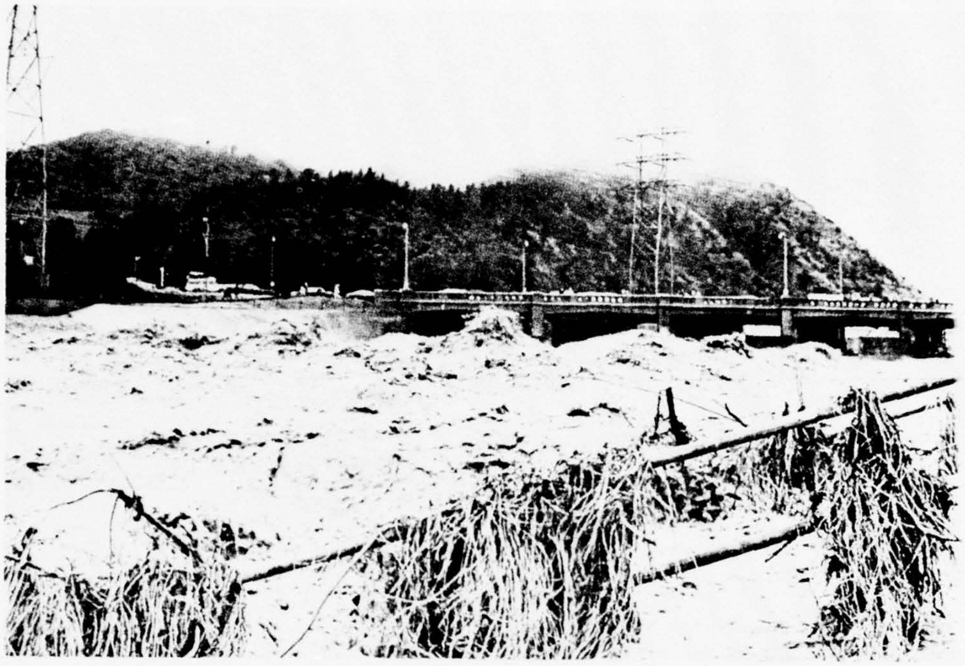


Flood damage along Santiago Creek in Santa Ana, February 1969. (Orange County Register Photo.)

PHOTO SC-I

Flood damage along Big Tujunga Wash, Los Angeles, February 1969. (KTLA Telecopter Photo by Harold Morby.)

PHOTO SC-II



Improved channel, Los Angeles River at Los Feliz Boulevard bridge, Los Angeles during January 1969 flood. (Los Angeles Times Photo.)

PHOTO SC-III

Hansen Flood Control Reservoir on Tujunga Wash, showing discharge during February 1969 flood. (Corps of Engineers Photo.)

PHOTO SC-IV

A number of other reservoirs in the subregion do not have flood control as a designated function. Some of these provide incidental flood control storage which at times can be significant.

Reservoir	Stream	Construction Agency
Lake Hodges	San Dieguito River	City of San Diego
San Vicente	San Diego River	City of San Diego
El Capitan	San Diego River	City of San Diego
Sweetwater	Sweetwater River	California-American Water Company
Lower Otay	Sweetwater River	City of San Diego
Barrett	Cottonwood Creek	City of San Diego
Morena	Cottonwood Creek	City of San Diego
Rodriquez*	Tijuana River	Mexico, D. F.

* In Baja, California.

An important element in the existing flood control system for this subregion is the extensive levee and channel system. The levee and channel system consisting of 114 miles of levee and 2,202 miles of channel, results from the joint effort of Federal and local agencies. Supplementing this system are 90 debris storage and flood water detention basins providing 7,218 acre-feet of storage and 2,154 acres of percolation beds for ground water recharge. The Federal portion of this system generally affords protection from a 1-in-100 year flood to standard project flood. The local agencies works which are generally along tributaries to main streams supplements the Federal works and affords protection ranging from 1-in-2 year to 1-in-50 year flood. In the Los Angeles County drainage area the Federal first cost amounts to $350 million (1970) whereas local interests have spent about $868 million (1970) for the required non-Federal cooperation and for projects described above as supplemental. Data concerning the existing (1965) levee and channel projects are in Table 7.

The Buena Vista and Calleguas Creek watershed protection projects have functioned effectively and provide excellent examples of comprehensive watershed projects wherein both structural and non-structural measures combine to provide needed flood protection while reducing erosion and sediment production. Additional effort will be necessary throughout the subregion to complete needed facilities of a comparable nature.

The Flood Plain Management Services Program is explained in detail in the Regional Summary of this appendix. No flood plain information studies have been completed in the South Coastal Subregion prior to 1965 and no flood hazard reports have been requested prior to that time.

The accomplishments of the existing flood control developments have been substantial. The system has functioned effectively to reduce flood-flows and to reduce flood damages. From their completion date to 1965, existing reservoir, levee, and channel projects have prevented damages estimated at $327 million. During the January-February floods in 1969, $900 million in damages were prevented in Los Angeles County drainage area alone. Average annual damages prevented by the system in the sub-region exceed $30 million. Additional details are included in Table 2.

As beneficial as the present flood control system has been, flood problems still exist. The problems are especially serious in the Santa Clara River, lower Calleguas Creek, Santa Ana River Basin, and in several basins in San Diego County. A large part of the flood damages occurring in the subregion result from inundation of urban properties. These damages are sometimes compounded by high-velocity flow and by deposition of sediment from upstream sheet and gully erosion. Flooding also occurs from standing water in poorly drained urban areas.

Streambank erosion in the subregion, while not as widespread as other forms of land erosion, is a serious problem. Streambank erosion occurs principally during winter rainstorms particularly those which cause short-duration, high-velocity flows. A total of 5,200 miles of streambanks have an erosion problem, 740 miles of which are considered serious. Approximately $700,000 a year is lost in direct land damage, and over $300,000 by downstream deposition of streambank sediment. As the demands upon land continue to grow throughout the subregion, erosion and sediment damages are expected to become more severe.

There is a continuing land treatment program in the upstream watershed areas. However, a serious problem exists in this subregion relating to brush fires and the aftermath--soil erosion. Soils are predominantly fine grained throughout the subregion. Denuding by fire of the steep terrain creates potential for movement of soil mantle during heavy rains. The sediment produced under such conditions contributes greatly to the downstream damages previously discussed.

The aforementioned flood problems have resulted in average annual damages as follows:

Study Area	Estimated Average Annual Damages ($1,000) 1/
Ventura River Basin	346
Santa Clara River Basin	2,068
Calleguas River Basin	1,105
Malibu Coastal Streams	144
Santa Monica Bay Streams	1,255
Los Angeles River Basin	1,546
San Gabriel River Basin	1,665
Santa Ana River Basin	9,475
Orange County Streams	148
Santa Margarita River Basin	790
San Luis Rey River Basin	929
San Dieguito River Basin	663
San Diego River Basin	1,184
Sweetwater River Basin	248
Otay-Tijuana Rivers Basin	144
Total South Coastal Subregion	21,710

1/ Based on 1965 prices, economic conditions, and project conditions.

Additional details are contained in Tables 3, 4, and 9. Major urban damage centers and areas of the subregion subject to flooding are shown on Map 4.

Future Needs

Flood damages will be greater in the future with no additional flood control improvements, because of the anticipated increase in urban development in the numerous flood plains of the area. Recent new developments and the continuing urban expansion of the area will greatly increase the value of property subject to overflow and damage by floods. The population of the South Coastal Subregion is projected to increase from 9,910,000 in 1965 to 13,895,000 in 1980, 19,200,000 in 2000, and 23,771,000 in 2020 (base plan projections). Floodways pass through some of the most intensively developed urban areas in the United States and through highly developed agricultural areas. An examination of current flood problems indicates that a number of additional flood control measures are needed to provide at least 100-year flood protection to the developing urban areas and 10-year to 50-year protection to the remaining agricultural areas. Table 5 indicates average annual flood damages may be expected to increase from $21.7 million in 1965 to $39.0 million by 1980, $82.2 million by 2000, and $185.9 million by 2020 if no additional flood control measures are provided after 1965. Of these amounts, average annual damages in urban centers are expected to increase from $7.6 million in 1965 to $14.7 million by 1980, $31.0 million by 2000, and $65.2 million by 2020. Estimated damage data for existing and future conditions are contained in Tables 5 and 9a.

Measures Required to Satisfy Future Needs

Improved flood forecasting will be an important part of the flood control program. The operation of flood control projects can only be assured by a well-coordinated system of forecasting and project operation. Although the Los Angeles County Flood Control District handles the flood forecasts for that county, areas in Ventura, Orange, San Diego, San Bernardino and Riverside Counties will need flood forecast services. An adequate hydrologic data telemetering network will have to be developed before much work can be done on flood forecasts because of the flashy nature of the streamflow and the short duration of runoff. Additional flood forecast points needed are shown on Map 4. The estimated costs of the required improvements to the flood forecasting system are $1.5 million for the 1966-1980 period, $1.2 million for 1981-2000 and $0.8 million for 2001-2020.

Additional flood water storage in reservoirs and detention basins needed in the future amounts to 557,000 acre-feet. Details are shown in the following tabulation:

Study Area - time frame in which needed		Detention structure or reservoir	Stream	Flood control capacity (ac.-ft.)	Drainage area (sq. mi.)
Santa Clara River Basin					
	1981-2000	Detention structures (3)	Various	2,000	10
	2001-2020	Topatopa	Sespe Creek	75,000	180
	2001-2020	Cold Springs	Sespe Creek	12,000	108
Calleguas Creek Basin					
	1981-2000	Calleguas	Arroyo Conejo	16,000	65
Malibu Coastal Streams					
	1981-2000	Detention structures (9)	Various	3,000	10
San Gabriel River Basin					
	1981-2000	Detention structures (15)	Various	7,000	14
Santa Ana River Basin					
	1966-1980	Prado	Santa Ana River	238,000	2,264
	1966-1980	Detention structures (13)	Various	18,000	140
	1981-2000	Salt Creek	Salt Creek	5,000	10
	1981-2000	Detention structures (21)	Various	18,000	126

Study Area - time frame in which needed	Detention structure or reservoir	Stream	Flood control capacity (ac.-ft.)	Drainage area (sq. mi.)
Orange County Streams				
1981-2000	San Juan Creek	San Juan Creek	30,000	106
1981-2000	Detention structures (3)	Various	1,000	30
Santa Margarita River Basin				
1981-2000	Deluz	Santa Margarita River	13,000 1/	705
San Luis Rey River Basin				
1981-2000	Monserate	San Luis Rey River	6,000	373
1981-2000	Detention structures (6)	Various	6,000	35
San Dieguito River Basin				
1966-1980	Detention structures (3)	Various	2,000	13
1981-2000	San Dieguito	San Dieguito River	92,000	303
2001-2020	Detention structures (2)	Various	3,000	18
San Diego River Basin				
1966-1980	Detention structure	No name	1,000	3
1981-2000	Detention structures (4)	Various	2,000	15
Sweetwater River Basin				
2001-2020	Detention structures (5)	Various	1,000	7
Otay-Tijuana Rivers Basin				
2001-2020	Detention structures (8)	Various	6,000	83
Total			557,000	

1/ Recent studies indicate that the 13,000 may be increased to as much as 40,000.

None of the reservoirs or detention structures listed above will be completed or under construction during the period 1965-1970. The reservoirs are shown on Map 3 and additional details are contained in Table 6. Estimated costs for additional flood control capacity amount to $92.3 million for the 1966-1980 period, $147.5 million for 1981-2000 and $34.6 million for 2001-2020.

Construction of the above reservoirs would only partially control the flood problem. A large part of the damages occur along other tributary streams and water courses where available reservoir sites do not exist. Thus, a future plan consisting of 134 miles of levee and 588 miles of channel is considered necessary (see Table 7 and Map 3). These levee and channel improvements would in some instances supplement the proposed reservoirs and detention structures, and in other instances would provide protection independently. Studies indicate that major levee and channel work is desirable in the following areas of the South Coastal Subregion:

Study area/time frame in which needed	Levees (Bank Miles)	Channels (Miles)
Ventura River Basin		
1966-1980	0	5
1981-2000	0	10
2001-2020	0	2
Santa Clara River Basin		
1966-1980	22	28
1981-2000	12	12
2001-2020	0	7
Calleguas Creek Basin		
1966-1980	0	17
1981-2000	0	18
2001-2020	4	30
Malibu Coastal Streams		
1981-2000	0	4
2001-2020	0	3
Santa Monica Bay Stream		
1966-1980	0	6
1980-2000	0	7
2001-2020	0	5
Los Angeles River Basin 1/		
1966-1980	0	6
1981-2000	0	16
2001-2020	0	8
San Gabriel River Basin 1/		
1966-1980	0	53
1981-2000	0	20
2001-2020	0	3

Study area/time frame in which needed	Levees (Bank Miles)	Channels (Miles)
Santa Ana River Basin		
1966-1980	4	95
1981-2000	40	89
2001-2020	38	45
Orange County Streams		
1981-2000	0	13
2001-2020	0	20
Santa Margarita River Basin		
1981-2000	0	1
2001-2020	0	4
San Luis Rey River Basin		
1966-1980	11	10
1981-2000	0	9
2001-2020	0	3
San Dieguito River Basin		
1966-1980	0	8
1981-2000	0	5
2001-2020	0	2
San Diego River Basin		
1966-1980	3	8
2001-2020	0	2
Sweetwater River Basin		
1966-1980	0	3
1981-2000	0	2
2001-2020	0	4
Otay-Tijuana Rivers Basin		
1966-1980	0	5
Total	134	588

1/ Under construction or funded for construction by FY 1970.

The approximate location of levees and channels are shown on Map 3 and additional details are included in Table 7. Of the amounts shown in the above tabulation, 5 miles of channel in the Los Angeles River Basin and 44 miles of channel in the San Gabriel River Basin will be completed or under construction in the period between 1965 and 1970. The estimated costs for

required levee and channel work are $286.6 million for the 1966-1980 period, $219.1 million for 1981-2000, and $169.2 million for 2001-2020.

Structural measures will be complemented by land treatment practices. The most frequently needed practices within this subregion are: fire prevention and suppression, brush control, critical area seeding and debris basins. See Map 3 for potential watershed project areas. Estimated costs and acres of watershed land treatment measures are summarized below.

Land Treatment	1966-1980	1981-2000	2001-2020
Thousand acres	81	247	152
Thousand dollars	7,800	17,900	10,800

Flood plain information reports will be an important adjunct to the overall flood control program. Forty-eight urban centers in the subregion have known significant flood problems. These centers are listed in Table 9 and are shown on Map 4. Many communities with expanding populations are expected to have flood problems in the future and will be studied as their needs are made known. From 1965 to June 1968 five flood plain information reports were completed in the subregion. It is anticipated that flood plain information reports for all the communities affected will be completed before the year 2000. Also, from 1965 to June 1968 sixty-three flood hazard reports were completed for both Federal and non-Federal agencies.

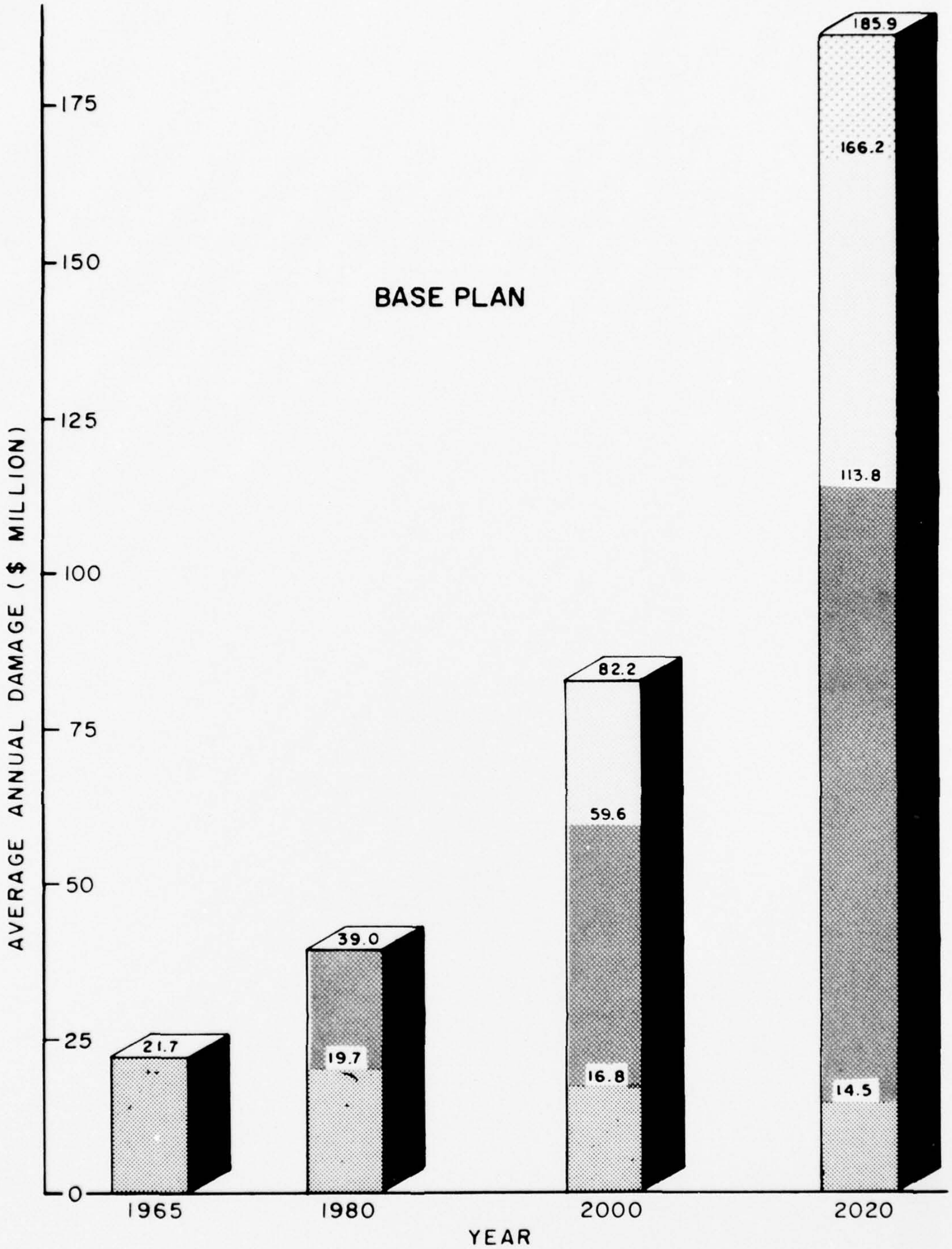
Non-structural measures of flood plain management will become a greater part of community planning in the South Coastal Subregion because of existing and anticipated flood problems not only in the present urban centers but also in the communities, now small, which will become future urban centers. Measures adopted will be primarily zoning and flood proofing. Most areas within the subregion have the potential for some reduction in damages attributable to these measures and about 230 miles are suitable. See Map 3 and Table 9b for principal areas where non-structural flood plain management measures are proposed.

Costs for future non-structural flood plain management measures are estimated at $32.9 million for the 1966-1980 period, $39.9 million for the 1981-2000 period, and $55.0 million for the 2001-2020 period. The effect of the potential flood control plan on future flood damages is presented next. Additional details are included in Table 8 and 9b.

Potential to Satisfy Future Needs

The flood control program presented herein would reduce the projected average annual damages $19.3 million by 1980, $65.4 million by 2000, and $171.4 million by 2020 at an estimated installation cost of

$421.1 million for the period 1966-1980, $425.6 million for 1981-2000, and $270.4 million for 2001-2020. Estimated annual OM&R costs for the 1966-1980, 1981-2000 and 2001-2020 portions of the flood control program are $3.21 million, $5.27 million and $4.03 million (See Tables 10, 10a and 10b). The effect of the potential flood control program on future damages is shown in Table 8 and graphically on Figure SC-1, and its effect on floodflows is shown in Table 11.



Damage Reduction due to 2001-2020 Flood Control Program

Damage Reduction due to 1981 - 2000 Flood Control Program

Damage Reduction due to 1966-1980 Flood Control Program

Residual Damage

CALIFORNIA REGION
COMPREHENSIVE FRAMEWORK STUDY

PROJECTED AVERAGE ANNUAL FLOOD DAMAGES
(1965 PRICES AND PROJECT CONDITIONS-DATA FROM TABLES 5 & 8)

APPENDIX IX FIGURE SC-1

TABLE I

SOUTH COASTAL SUBREGION OF THE CALIFORNIA REGION

Historical Flood Data

Study area	Flood	Location/ flow (cfs)	Area inundated (1,000 acres)	Flood damages 1/ - ($1,000) Forest & range resources	Forest & range facilities	Crop & pasture	Other agricultural	Land	Residential & commercial	Industrial & utility	Public facilities	Total
1	2	3	4	5	6	7	8	9	10	11	12	13
Ventura River Basin		Ventura										
	Mar38	39,200	6.0	0	216	50	90	50	575	480	91	1,552
	Jan69	54,900	N.A.	0	0	2,200	550	260	670	4,217	3,103	11,000
	Feb69	40,000	N.A.	0	0	880	220	102	428	1,097	2,012	4,739
Santa Clara River Basin		Montalvo										
	Mar38	115,000	5.0	0	500	1,000	0	391	100	1,078	1,531	4,600
	Feb44	60,000	1.5	0	290	60	0	300	0	272	274	1,196
	Jan69	165,000	N.A.	0	0	2,560	703	136	3,594	3,230	5,008	15,231
	Feb69	152,000	N.A.	0	0	3,100	980	192	4,498	3,893	12,951	25,614
Calleguas Creek Basin		Camarillo										
	Jan69	9,900	N.A.	0	0	911	226	30	67	792	964	2,990
	Feb69	N.A.	N.A.	0	0	310	76	22	25	511	340	1,284
Santa Monica Bay Streams		Culver City										
	Mar38	19,000	9.4	0	0	0	79	15	2,214	1,774	962	5,014
	Feb54	4,300	.2	0	0	0	0	0	48	0	2	50
Los Angeles River Basin		Los Angeles										
	Mar38	67,000	25.0	0	100	229	307	1,631	8,975	3,472	10,850	25,564
	Jan52	25,300	N.A.	0	90	0	153	0	541	753	2,764	4,301
	Jan56	15,300	N.A.	0	102	0	2	0	5	0	1,113	1,222
	Jan69	41,800	N.A.	0	0	0	0	0	1,529	33	1,424	2,986
	Feb69	34,100	N.A.	0	0	0	0	0	270	167	2,190	2,627
San Gabriel River Basin		Pico										
	Mar38	22,700	6.3	0	140	88	562	1,122	2,023	1,978	801	6,714
		Artesia										
	Mar38	3,610	5.0	0	0	0	1,734	14	4,743	369	225	7,085
		Pico										
	Jan69	11,800	N.A.	0	0	0	0	0	919	56	1,609	2,564
	Feb69	11,200	N.A.	0	0	0	0	0	188	8	599	795
Santa Ana River Basin		near Arlington										
	Jan16	45,000	80.0	0	35	0	760	440	2,100	680	3,600	7,615
	Mar38	100,000	178.0	0	45	0	2,000	1,203	5,738	1,855	9,916	20,757
	Jan43	18,400	45.0	0	25	0	150	140	450	200	900	1,865
	Nov65	25,400	5.0	0	235	0	100	0	440	570	3,660	5,005
	Jan69	35,000	N.A.	0	0	0	4,825	0	8,569	9,275	13,462	36,131
	Feb69	34,000	N.A.	0	0	0	7,325	0	13,737	13,841	17,190	52,093
Sante Margarita River Basin		Ysidora										
	Jan16	66,500	4.5	12	25	80	60	60	0	652	200	1,089
	Mar38	31,000	3.0	6	12	23	20	20	0	3	15	99
	Feb69	19,200	N.A.	0	0	0	0	16	0	230	1,381	1,627
San Luis Rey River Basin		Oceanside										
	Jan16	95,600	4.0	1	28	200	0	300	0	200	300	1,029
	Mar38	16,500	1.0	1	15	30	0	22	90	6	25	189
	Feb69	5,000	N.A.	0	0	0	0	0	165	70	227	462
San Diego River Basin		Santee										
	Jan16	70,200	2.0	0	0	20	0	0	300	200	45	565
	Feb27	45,400	1.0	0	0	5	0	0	68	37	8	118
Sweetwater River Basin		Sweetwater										
	Jan16	47,600	1.0	0	18	0	0	100	0	100	200	418
	Feb27	33,900	.5	0	13	0	0	0	85	5	10	113
Tijuana River Basin		Nestor										
	Jan16	75,000	5.0	0	65	50	50	100	0	0	0	265
	Mar38	6,760	4.0	0	15	0	0	0	0	0	64	79

1/ Data based on prices and project and economic conditions at time of occurrence of flood.
N.A. - Not Available

TABLE 2

SOUTH COASTAL SUBREGION OF THE CALIFORNIA REGION

Flood Damage 1/

Study area	Flood	Location/ flow (cfs)	Total damages - ($1,000)					
			At time of flood 2/			1965 economic conditions & prices 3/		
			Actual damage	Damage without flood control projects	Damage prevented by flood control projects 4/	Damage with 1965 project conditions	Damage without flood control projects	Damage prevented by 1965 projects 5/
1	2	3	4	5	6	7	8	9
Ventura River Basin		Ventura						
	Mar38	39,200	1,552	1,552	0	1,670	11,620	9,950
	Jan69	54,900	11,000	14,000	3,000	8,800	11,200	2,400
Santa Clara River Basin		Montalvo						
	Mar38	115,000	4,600	4,600	0	14,800	27,800	13,000
	Feb69	165,000	25,614	63,614	38,000	20,000	50,000	30,000
Santa Monica Bay Streams		Culver City						
	Mar38	19,000	5,014	5,014	0	1,150	49,250	48,100
Los Angeles River Basin		Los Angeles						
	Mar38	67,000	25,564	25,564	0	5,900	250,900	245,000
San Gabriel River Basin		Pico						
	Mar38	22,700	6,714	6,714	0	2,560	65,360	62,800
	Mar38	3,610	7,085	7,085	0	1,000	69,000	68,000
Santa Ana River Basin		near Arlington						
	Mar38	100,000	20,757	20,757	0	3,400	100,400	97,000
Santa Margarita River Basin		Ysidora						
	Jan16	66,500	1,089	1,089	0	6,000	6,000	0
	Feb69	19,200	1,627	1,627	0	1,300	1,300	0
San Luis Rey River Basin		Oceanside						
	Jan16	95,600	1,029	1,029	0	7,200	7,200	0
	Feb69	11,500	462	462	0	370	370	0
San Diego River Basin		Santee						
	Jan16	70,200	565	565	0	7,300	7,300	0
Sweetwater River Basin		Sweetwater						
	Jan16	47,600	418	418	0	3,800	3,800	0
Tijuana River Basin		Nestor						
	Jan16	75,000	265	265	0	1,760	1,760	0

1/ Maximum flood for which data are available.
2/ Data based on prices and project and economic conditions at time of occurrence of flood.
3/ Data based on recurrence of original flood.
4/ Column 6 = Col. 5 - Col. 4
5/ Column 9 = Col. 8 - Col. 7

TABLE 3

SOUTH COASTAL SUBREGION OF THE CALIFORNIA REGION

Estimated Flood Damage for
the 100-Year Frequency Flood 1/
for Selected Streams

Study area/ stream	Area inundated (1,000 acres)	Flood damage 2/ - ($1,000)								
		Forest & range resources	Forest & range facilities	Crop & pasture	Other agricul- tural	Land	Residential & commercial	Industrial & utilities	Public facilities	Total
1	2	3	4	5	6	7	8	9	10	11
Ventura River Basin Ventura River	2.2	0	490	1,160	314	3	365	676	427	3,435
Santa Clara River Basin Santa Clara River	20.0	0	3,888	1,907	470	46	13,017	2,090	1,539	22,957
Calleguas Creek Basin Calleguas Creek	27.5	0	0	7,963	729	85	5,964	4,504	2,806	22,051
Malibu Coastal Streams Topanga Canyon	4.0	0	0	76	27	86	723	195	519	1,626
Santa Monica Bay Streams Ballona Creek	55.0	0	0	760	110	500	10,200	3,260	3,770	18,600
Los Angeles River Basin Los Angeles River	130.0	0	1,021	83	83	487	2,810	1,125	3,450	9,059
San Gabriel River Basin San Gabriel River	70.6	0	1,437	223	96	1,345	1,700	515	1,504	6,820
Santa Ana River Basin Santa Ana River	87.7	0	405	9,750	9,160	4,780	102,882	45,432	39,400	211,809
Orange County Streams San Juan Creek	7.0	0	51	270	690	37	624	0	1,292	2,964
Santa Margarita River Basin Santa Margarita River	16.6	15	48	225	413	689	104	750	6,770	9,014
San Luis Rey River Basin San Luis Rey River	17.0	1	31	2,214	1,085	506	4,408	292	1,161	9,698
San Dieguito River Basin San Dieguito River	5.4	0	51	132	1,895	361	3,572	151	931	7,093
San Diego River Basin San Diego River	10.9	0	0	618	108	26	15,590	3,758	1,858	21,958
Sweetwater River Basin Sweetwater River	3.0	0	19	26	1	1	6,181	655	1,030	7,913
Otay-Tijuana Rivers Basin Otay River	5.9	0	67	75	116	326	1,035	148	470	2,237

1/ See Table 11 for magnitude of 100-year flood at selected stations.
2/ Based on July 1965 prices, economic conditions, and project conditions.

TABLE 4

SOUTH COASTAL SUBREGION OF THE CALIFORNIA REGION

Estimated Average Annual Flood Damage

Study area (principal stream)	Flood damage 1/ - ($1,000) Forest & range resources	Forest & range facilities	Crop & pasture	Other agricultural	Land	Residential & commercial	Industrial & utilities	Public facilities	Study area totals
1	2	3	4	5	6	7	8	9	10
Ventura River Basin (Ventura River)	0	98	110	33	1	33	32	39	346
Santa Clara River Basin (Santa Clara River)	0	778	222	102	13	756	100	97	2,068
Calleguas Creek Basin (Calleguas Creek)	0	0	402	45	9	316	204	129	1,105
Malibu Coastal Streams (Topanga Canyon)	0	0	25	8	29	46	10	26	144
Santa Monica Bay Streams (Ballona Creek)	0	0	55	5	35	685	220	255	1,255
Los Angeles River Basin (Los Angeles River)	0	205	13	13	81	469	188	577	1,546
San Gabriel River Basin (San Gabriel River)	0	288	89	40	360	529	91	268	1,665
Santa Ana River Basin (Santa Ana River)	0	81	653	425	429	4,112	2,131	1,644	9,475
Orange County Streams (San Juan Creek)	0	4	10	37	12	31	1	53	148
Santa Margarita River Basin (San Margarita River)	5	10	41	117	390	5	17	205	790
San Luis Rey River Basin (San Luis Rey River)	0	6	162	177	140	341	29	74	929
San Dieguito River Basin (San Dieguito River)	0	11	17	306	76	186	11	56	663
San Diego River Basin (San Diego River)	0	0	29	5	7	892	156	95	1,184
Sweetwater River Basin (Sweetwater River)	0	4	1	0	0	191	20	32	248
Otay-Tijuana Rivers Basin (Otay River)	0	14	31	3	10	47	3	36	144
Total South Coastal Subregion	5	1,499	1,860	1,316	1,592	8,639	3,213	3,586	21,710

1/ Damages based on July 1965 prices, economic conditions and project conditions.

TABLE 5

SOUTH COASTAL SUBREGION OF THE CALIFORNIA REGION

Summary of Estimated Average Annual Flood Damage for Present
and Future Conditions of Economic Development
with Existing Flood Control Measures

Study area (principal stream)	Average annual flood damages 1/ - ($1,000)			
	1965 economic conditions 2/	1980 economic conditions	2000 economic conditions	2020 economic conditions
1	2	3	4	5
Ventura River Basin (Ventura River)	346	450	790	1,310
Santa Clara River Basin (Santa Clara River)	2,068	3,625	8,760	26,020
Calleguas Creek Basin (Calleguas Creek)	1,105	2,168	4,690	10,825
Malibu Coastal Streams (Topanga Canyon)	144	280	500	920
Santa Monica Bay Streams (Ballona Creek)	1,255	1,865	3,040	4,800
Los Angeles River Basin (Los Angeles River)	1,546	2,200	3,450	5,370
San Gabriel River Basin (San Gabriel River)	1,665	2,250	3,255	4,460
Santa Ana River Basin (Santa Ana River)	9,475	18,800	43,285	106,425
Orange County Streams (San Juan Creek)	148	253	440	960
Santa Margarita River Basin (Santa Margarita River)	790	1,140	2,270	4,150
San Luis Rey River Basin (San Luis Rey River)	929	1,720	3,365	5,310
San Dieguito River Basin (San Dieguito River)	663	1,070	1,965	2,990
San Diego River Basin (San Diego River)	1,184	2,335	4,665	9,240
Sweetwater River Basin (Sweetwater River)	248	540	1,230	2,160
Otay-Tijuana Rivers Basin (Otay River)	144	260	535	870
Total South Coastal Subregion	21,710	38,956	82,240	185,830

1/ Damages based on July 1965 prices and project conditions and estimated economic conditions for the year shown.
2/ Figures in Column 2 are from Column 10 of Table 4.

TABLE 6

SOUTH COASTAL SUBREGION OF THE CALIFORNIA REGION

Summary of Flood Control Capacity for Existing and Future Reservoirs

Study area	Flood control capacity 1/ - (1,000 ac-ft)				
	Existing projects (1965)	Projects 1966-1980 2/	Projects 1981-2000 2/	Projects 2001-2020 2/	Total projects as of 2020
1	2	3	4	5	6
Ventura River Basin	0	0	0	0	0
Santa Clara River Basin	0	0	2	87	89
Calleguas Creek Basin	0	0	16	0	16
Malibu Coastal Streams	0	0	3	0	3
Santa Monica Bay Streams	0	0	0	0	0
Los Angeles River Basin	56	0	0	0	56
San Gabriel River Basin	110	0	7	0	117
Santa Ana River Basin	271	256	23	0	550
Orange County Streams	0	0	31	0	31
Santa Margarita River Basin	0	0	13 3/	0	13
San Luis Rey River Basin	1	0	12	0	13
San Dieguito River Basin	0	2	92	3	97
San Diego River Basin	0	1	2	0	3
Sweetwater River Basin	0	0	0	1	1
Otay-Tijuana Rivers Basin	0	0	0	6	6
Total South Coastal Subregion	438	259	201	97	995

1/ Maximum flood control capacity. Does not include surcharge storage.
2/ Includes only reservoirs controlling the 100-year flood, or better, at the damsite above urban areas and reservoirs controlling at least the 10-year flood at the damsite where only rural areas are to be protected.
3/ Recent studies indicate that the 13 may be increased to as much as 40.

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TABLE 7

SOUTH COASTAL SUBREGION OF THE CALIFORNIA REGION

Summary of Levee and Channel Flood Protection Projects
- Existing and Future -

Study area	Levee and channel projects									
	Existing projects (1965)		Projects 1966-1980 1/		Projects 1981-2000 1/		Projects 2001-2020 1/		Total projects as of 2020	
	Levees (miles)	Channels (miles)	Levees (miles)	Channels (miles)	Levees (miles)	Channels (miles)	Levees (miles)	Channels (miles)	Levees (miles)	Channels (miles)
1	2	3	4	5	6	7	8	9	10	11
Ventura River Basin	11	81	0	5	0	10	0	2	11	98
Santa Clara River Basin	5	3	22	28	12	12	0	7	39	50
Calleguas Creek Basin	0	14	0	17	0	18	4	30	4	79
Malibu Coastal Streams	0	0	0	0	0	4	0	3	0	7
Santa Monica Bay Streams	0	161	0	6	0	7	0	5	0	179
Los Angeles River Basin	0	1,358	0	6	0	16	0	8	0	1,388
San Gabriel River Basin	0	443	0	53	0	20	0	3	0	519
Santa Ana River Basin	71	92	4	95	40	89	38	45	153	321
Orange County Streams	18	22	0	0	0	13	0	20	18	55
Santa Margarita River Basin	2	0	0	0	0	1	0	4	2	5
San Luis Rey River Basin	1	13	11	10	0	9	0	3	12	35
San Dieguito River Basin	0	3	0	8	0	5	0	2	0	18
San Diego River Basin	6	3	3	8	0	0	0	2	9	13
Sweetwater River Basin	0	9	0	3	0	2	0	4	0	18
Otay-Tijuana Rivers Basin	0	0	0	5	0	0	0	0	0	5
Total South Coastal Subregion	114	2,202	40	244	52	206	42	138	248	2,790

1/ Includes only projects giving 100-year flood protection, or better, to urban areas and at least 10-year flood protection to agricultural areas.

June 1971

TABLE 8

SOUTH COASTAL SUBREGION OF THE CALIFORNIA REGION

Estimated Average Annual Flood Damage and Damage Reduction
- Present and Future Economic Conditions -

Study area (principal stream)	Total damages - 1965 prices ($1,000)									
	1965 economic & project conditions 1/	1980 economic conditions			2000 economic conditions			2020 economic conditions		
		W/1965 project conditions 2/	Reduction in damages due to 1966-1980 flood control program 3/	Residual damage W/ 1966-1980 program 4/	W/1966-1980 program	Reduction in damages due to 1981-2000 flood control program 3/	Residual damage W/ 1981-2000 program 5/	W/1981-2000 program	Reduction in damages due to 2001-2020 flood control program 3/	Residual damage W/ 2001-2020 program 6/
1	2	3	4	5	6	7	8	9	10	11
Ventura River basin (Ventura River)	346	450	153	297	529	224	305	534	90	444
Santa Clara River Basin (Santa Clara River)	2,068	3,625	1,769	1,856	3,525	1,500	2,025	3,728	1,158	2,570
Calleguas Creek Basin (Calleguas Creek)	1,105	2,168	1,118	1,050	2,315	1,593	722	1,425	670	755
Malibu Coastal Streams (Topanga Canyon)	144	280	20	260	483	318	165	330	240	90
Santa Monica Bay Streams (Ballona Creek)	1,255	1,865	690	1,175	1,900	920	980	1,550	600	950
Los Angeles River Basin (Los Angeles River)	1,546	2,200	816	1,384	2,210	1,190	1,020	1,590	670	920
San Gabriel River Basin (San Gabriel River)	1,665	2,250	745	1,505	2,210	1,460	750	1,030	450	580
Santa Ana River Basin (Santa Ana River)	9,475	18,800	10,415	8,385	19,270	11,973	7,297	18,020	12,964	5,056
Orange County Streams (San Juan Creek)	148	253	4	249	479	234	245	541	375	166
Santa Margarita River Basin (Santa Margarita River)	790	1,140	73	1,067	2,100	1,367	733	1,410	800	610
San Luis Rey River Basin (San Luis Rey River)	929	1,720	725	995	1,815	1,070	745	1,135	440	695
San Dieguito River Basin (San Dieguito River)	663	1,070	271	799	1,340	289	1,051	1,454	412	1,042
San Diego River Basin (San Diego River)	1,184	2,335	2,014	321	599	277	322	633	309	324
Sweetwater River Basin (Sweetwater River)	248	540	366	174	380	135	245	455	322	133
Otay-Tijuana Rivers Basin (Otay River)	144	260	133	127	234	24	210	330	212	118
Total South Coastal Subregion	21,710	38,956	19,312	19,644	39,389	22,574	16,815	34,165	19,712	14,453

1/ Figures shown in Column 2 are from Column 10 of Table 4 and are also shown in Column 2 of Table 5.
2/ Figures in Column 3 are from Column 3 of Table 5.
3/ Includes structural and non-structural measures.
4/ Column 5 = Column 3 - Column 4.
5/ Column 8 = Column 6 - Column 7.
6/ Column 11 = Column 9 - Column 10.

TABLE 9

SOUTH COASTAL SUBREGION OF THE CALIFORNIA REGION

Estimated Average Annual Flood Damage for Urban Areas with Significant Flood Problems

Study area/ stream	Damage center	Average annual flood damages ($1,000) 1/ Residential	Commercial	Industrial & utilities	Public facilities	Total
1	2	3	4	5	6	7
Ventura River Basin						
Ventura River	Ventura	3	2	3	7	15
Ventura River	Meiner's Oaks	5	2	3	1	11
Stewart Wash	Ojai	13	8	10	37	68
Subtotal		21	12	16	45	94
Santa Clara River Basin						
Santa Clara River	Oxnard	40	60	10	10	120
Santa Clara River	El Rio	70	30	10	8	118
Santa Clara River	Santa Paula	75	48	7	5	135
Santa Clara River	Fillmore	195	113	7	4	319
Santa Clara River	Newhall	30	21	6	6	63
Subtotal		410	272	40	33	755
Calleguas Creek Basin						
Calleguas Creek	Camarillo	70	60	95	60	285
Arroyo Conejo	Thousand Oaks	7	3	5	5	20
Arroyo Simi	Moorpark	60	40	90	50	240
Subtotal		137	103	190	115	545
Santa Monica Streams						
Laguna Dominguez	Los Angeles	7	5	15	220	247
Benedict Canyon	Beverly Hills	11	1	8	200	220
Benedict Canyon	West Hollywood	10	2	6	180	198
Centinela Creek	Inglewood	6	6	10	250	272
Ballona Creek	Culver City	20	15	3	10	48
Sepulveda Canyon	Santa Monica	8	4	8	190	210
Subtotal		62	33	50	1,050	1,195
Los Angeles River Basin						
Los Angeles River	Los Angeles	135	100	94	287	616
Los Angeles River	Burbank	50	28	31	97	206
Los Angeles River	Glendale	72	20	44	109	245
Los Angeles River	La Canada	50	15	18	84	167
Subtotal		307	163	187	577	1,234
San Gabriel River Basin						
Arcadia Wash	Arcadia	25	15	10	35	85
Big Dalton Wash	Baldwin Park	35	20	15	40	110
Walnut Creek	Covina	30	15	17	30	92
San Gabriel River	Duarte	30	20	25	15	90
Coyote Creek	E. Whittier	20	15	10	25	70
Little Dalton Wash	Glendora	35	15	20	30	100
Coyote Creek	La Mirada	30	10	35	10	85
San Jose Creek	La Puente	25	10	30	10	75
Subtotal		230	120	162	195	707
Santa Ana River Basin						
San Antonio Creek	Chino	12	6	2	9	29
Cucamonga Creek	Upland	75	25	22	45	167
Cucamonga Creek	Ontario	100	53	32	53	238
Warm Creek	San Bernardino	110	65	82	64	321
Mill Creek	Redlands	170	55	12	10	247
Santa Ana River	Riverside	20	10	10	4	44
Temescal Creek	Corona	80	31	12	14	137
Bautista Creek	San Jacinto	28	8	4	5	45
San Jacinto River	Perris	2	1	1	2	6
Santa Ana River	Santa Ana	15	5	25	31	76
Subtotal		612	259	202	237	1,310
Orange County Streams						
Laguna Creek	Laguna Beach	4	1	1	2	8
San Luis Rey River Basin						
San Luis Rey River	Oceanside	100	50	2	32	184
Buena Vista Creek	Vista	8	4	1	0	13
San Marcos Creek	Leucadia	80	20	5	5	110
Subtotal		188	74	8	37	307
San Dieguito River Basin						
San Dieguito River	Del Mar	68	30	0	13	111
San Diego River Basin						
San Diego River	San Diego	277	156	145	56	634
San Diego River	El Cajon	250	139	10	34	433
Subtotal		527	295	155	90	1,067

TABLE 9

SOUTH COASTAL SUBREGION OF THE CALIFORNIA REGION (Cont'd)

Estimated Average Annual Flood Damage for Urban Areas with Significant Flood Problems

Study area/ stream	Damage center	Average annual flood damages ($1,000) 1/ Residential	Commercial	Industrial & utilities	Public facilities	Total
1	2	3	4	5	6	7
Sweetwater River Basin						
Las Chollas Creek	San Diego	17	8	15	10	50
Sweetwater River	National City	53	20	3	12	88
Sweetwater River	Chula Vista	35	15	2	9	61
Subtotal		105	43	20	31	199
Otay-Tijuana Rivers Basin						
Otay-Tijuana River	Imperial Beach	30	16	3	36	85
Total South Coastal Subregion		2,701	1,421	1,034	2,461	7,617

1/ Damages are based on July 1965 prices, economic conditions, and project conditions.

TABLE 9a

SOUTH COASTAL SUBREGION OF THE CALIFORNIA REGION

Summary of Estimated Average Annual Flood Damage for Urban Areas with Significant Flood Problems
- Present and Future Conditions of Economic Development
with Existing Flood Control Measures -

Study area/ stream	Damage center	Average annual flood damages 1/ - ($1,000) 1965 economic conditions 2/	1980 economic conditions	2000 economic conditions	2020 economic conditions
1	2	3	4	5	6
Ventura River Basin					
Ventura River	Ventura	15	23	60	120
Ventura River	Meiner's Oaks	11	16	44	88
Stewart Wash	Ojai	68	102	272	542
Subtotal		94	141	376	750
Santa Clara River Basin					
Santa Clara River	Oxnard	120	300	750	1,875
Santa Clara River	El Rio	118	295	735	1,835
Santa Clara River	Santa Paula	135	338	845	2,120
Santa Clara River	Fillmore	319	795	1,990	4,970
Santa Clara River	Newhall	63	152	380	950
Subtotal		755	1,880	4,700	11,750
Calleguas Creek Basin					
Calleguas Creek	Camarillo	285	710	1,775	4,450
Arroyo Conejo	Thousand Oaks	20	50	125	300
Arroyo Simi	Moorpark	240	600	1,500	3,750
Subtotal		545	1,360	3,400	8,500
Santa Monica Bay Streams					
Laguna Dominguez	Los Angeles	247	370	610	970
Benedict Canyon	Beverly Hills	220	330	550	880
Benedict Canyon	West Hollywood	198	300	500	800
Centinela Creek	Inglewood	272	410	670	1,070
Ballona Creek	Culver City	48	70	110	170
Sepulveda Canyon	Santa Monica	210	310	510	810
Subtotal		1,195	1,790	2,950	4,700
Los Angeles River Basin					
Los Angeles River	Los Angeles	616	920	1,520	2,430
Los Angeles River	Burbank	206	310	510	830
Los Angeles River	Glendale	245	370	610	980
Los Angeles River	La Canada	167	250	410	660
Subtotal		1,234	1,850	3,050	4,900
San Gabriel River Basin					
Arcadia Wash	Arcadia	85	130	230	370
Big Dalton Wash	Baldwin Park	110	165	260	415
Walnut Creek	Covina	92	135	225	360
San Gabriel River	Duarte	90	135	215	345
Coyote Creek	East Whittier	70	105	170	270
Little Dalton Wash	Glendora	100	150	240	380
Coyote Creek	La Mirada	85	130	230	370
San Jose Creek	La Puente	75	110	180	290
Subtotal		707	1,060	1,750	2,800
Santa Ana River Basin					
San Antonio Creek	Chino	29	60	145	360
Cucamonga Creek	Upland	167	350	840	2,100
Cucamonga Creek	Ontario	238	500	1,200	3,000
Warm Creek	San Bernardino	321	675	1,620	4,050
Mill Creek	Redlands	247	518	1,250	3,120
Santa Ana River	Riverside	44	90	230	570
Temescal Creek	Corona	137	288	590	1,470
Bautista Creek	San Jacinto	45	95	220	550
San Jacinto River	Perris	6	13	30	70
Santa Ana River	Santa Ana	76	151	375	1,060
Subtotal		1,310	2,740	6,500	16,350
Orange County Streams					
Laguna Creek	Laguna Beach	8	16	32	80
San Luis Rey River Basin					
San Luis Rey River	Oceanside	184	415	970	1,650
Buena Vista Creek	Vista	13	45	95	160
San Marcos Creek	Leucadia	110	370	880	1,500
Subtotal		307	830	1,945	3,310
San Dieguito River Basin					
San Dieguito River	Del Mar	111	250	590	1,000
San Diego River Basin					
San Diego River	San Diego	634	1,271	2,561	5,080
San Diego River	El Cajon	433	864	1,744	3,500
Subtotal		1,067	2,135	4,305	8,580

Base Plan

TABLE 9a

SOUTH COASTAL SUBREGION OF THE CALIFORNIA REGION (CONT'D)

Summary of Estimated Average Annual Flood Damage for Urban Areas with Significant Flood Problems
- Present and Future Conditions of Economic Development
with Existing Flood Control Measures -

Study area/ stream	Damage center	Average annual flood damages 1/ - ($1,000) 1965 economic conditions 2/	1980 economic conditions	2000 economic conditions	2020 economic conditions
1	2	3	4	5	6
Sweetwater River Basin					
Los Chollas Creek	San Diego	50	100	200	400
Sweetwater River	National City	88	198	470	800
Sweetwater River	Chula Vista	61	138	320	550
Subtotal		199	436	990	1,750
Otay-Tijuana Rivers Basin					
Otay-Tijuana River	Imperial Beach	85	191	450	768
Total South Coastal Subregion		7,617	14,679	31,038	65,238

1/ Damages based on July 1965 prices and project conditions and estimated economic conditions for the year shown.
2/ Figures in Column 3 are from Column 7 of Table 9.

June 1971

TABLE 9b

SOUTH COASTAL SUBREGION OF THE CALIFORNIA REGION

Estimated Average Annual Flood Damage and Damage Reduction
for Urban Areas with Significant Flood Problems
- Present and Future Economic Conditions -

Study area/ stream	Damage center	Total damages - 1965 prices ($1,000): 1965 economic & project conditions 1/	1980 economic conditions: W/1965 project conditions 2/	1980 economic conditions: Reduction due to 1966-1980 program: Non-structural measures	1980 economic conditions: Reduction due to 1966-1980 program: Structural measures	1980 economic conditions: Residual damage w/1966-1980 program 3/	2000 economic conditions: W/1966-1980 program	2000 economic conditions: Reduction due to 1981-2000 program: Non-structural measures	2000 economic conditions: Reduction due to 1981-2000 program: Structural measures	2000 economic conditions: Residual damage w/1981-2000 program 4/	2020 economic conditions: W/1981-2000 program	2020 economic conditions: Reduction due to 2001-2020 program: Non-structural measures	2020 economic conditions: Reduction due to 2001-2020 program: Structural measures	2020 economic conditions: Residual damage w/2001-2020 program 5/
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Ventura River Basin														
Ventura River	Ventura	15	23	0	12	11	30	0	18	12	24	3	18	3
Ventura River	Meiner's Oaks	11	16	7	0	9	24	10	0	14	28	4	17	7
Stewart Wash	Ojai	68	102	15	42	45	120	0	90	30	60	30	0	30
Subtotal		94	141	22	54	65	174	10	108	56	112	37	35	40
Santa Clara River Basin														
Santa Clara River	Oxnard	120	300	70	0	230	575	20	515	40	100	50	0	50
Santa Clara River	El Rio	118	295	70	0	225	560	20	500	40	100	50	0	50
Santa Clara River	Santa Paula	135	338	60	226	52	130	0	110	20	58	17	30	11
Santa Clara River	Fillmore	319	795	0	715	80	200	0	0	200	500	10	475	15
Santa Clara River	Newhall	63	152	0	143	9	25	10	0	15	30	14	0	16
Subtotal		755	1,880	200	1,084	596	1,490	50	1,125	315	788	141	505	142
Calleguas Creek Basin														
Calleguas Creek	Camarillo	285	710	0	570	140	350	105	35	210	525	140	10	375
Arroyo Conejo	Thousand Oaks	20	50	20	0	30	75	20	0	55	135	65	0	70
Arroyo Simi	Moorpark	240	600	40	0	560	1,400	0	1,260	140	350	70	175	105
Subtotal		545	1,360	60	570	730	1,825	125	1,295	405	1,010	275	185	550
Santa Monica Bay Streams														
Laguna Domingues	Los Angeles	247	370	110	0	260	430	140	100	190	300	90	50	160
Benedict Canyon	Beverly Hills	220	330	95	0	235	390	170	55	165	260	80	0	180
Benedict Canyon	West Hollywood	198	300	80	0	220	360	100	55	205	330	85	0	245
Centinela Creek	Inglewood	272	410	95	0	315	520	190	40	290	460	135	100	225
Ballona Creek	Culver City	48	70	10	0	60	100	20	0	80	130	20	0	110
Sepulveda Canyon	Santa Monica	210	310	60	220	30	50	30	0	20	40	30	0	10
Subtotal		1,195	1,790	450	220	1,120	1,850	650	250	950	1,520	440	150	930
Los Angeles River Basin														
Los Angeles River	Los Angeles	616	920	0	500	420	700	0	600	100	160	0	140	20
Los Angeles River	Burbank	206	310	110	0	200	330	140	0	190	300	0	230	70
Los Angeles River	Glendale	245	370	110	0	260	430	110	200	120	190	35	75	80
Los Angeles River	La Canada	167	250	70	0	180	300	110	0	190	300	50	110	140
Subtotal		1,234	1,850	290	500	1,060	1,760	360	600	600	950	85	555	310
San Gabriel River Basin														
Arcadia Wash	Arcadia	85	130	0	115	15	25	0	0	25	40	15	0	25
Big Dalton Wash	Baldwin Park	110	165	70	0	95	155	70	0	85	135	0	90	45
Walnut Creek	Covina	92	135	70	0	65	110	40	0	70	110	50	0	60
San Gabriel River	Duarte	90	135	60	0	75	125	60	0	65	105	45	0	60
Coyote Creek	East Whittier	70	105	0	80	25	40	0	0	40	65	25	0	40
Little Dalton Wash	Glendora	100	150	50	0	100	165	70	0	95	150	0	120	30
Coyote Creek	La Mirada	85	130	0	105	25	40	0	0	40	65	25	0	40
San Jose Creek	La Puente	75	110	0	100	10	20	0	0	20	30	10	0	20
Subtotal		707	1,060	250	400	410	680	240	0	440	700	170	210	320

TABLE 9b

SOUTH COASTAL SUBREGION OF THE CALIFORNIA REGION (Cont'd)

Estimated Average Annual Flood Damage and Damage Reduction
for Urban Areas with Significant Flood Problems
- Present and Future Economic Conditions -

Study area/ stream	Damage center	Total damages - 1965 prices ($1,000)												
		1965	1980 economic conditions				2000 economic conditions				2020 economic conditions			
		economic & project conditions 1/	W/1965 project conditions 2/	Reduction due to 1966-1980 program: Non-structural measures	Reduction due to 1966-1980 program: Structural measures	Residual damage w/1966-1980 program 3/	W/1966-1980 program	Reduction due to 1981-2000 program: Non-structural measures	Reduction due to 1981-2000 program: Structural measures	Residual damage w/1981-2000 program 4/	W/1981-2000 program	Reduction due to 2001-2020 program: Non-structural measures	Reduction due to 2001-2020 program: Structural measures	Residual damage w/2001-2020 program 5/
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Santa Ana River Basin														
San Antonio Creek	Chino	29	60	0	0	60	144	0	132	12	30	15	0	15
Cucamonga Creek	Upland	167	350	35	180	135	324	140	0	184	460	140	140	180
Cucamonga Creek	Ontario	238	500	0	455	45	100	20	55	25	62	20	0	42
Warm Creek	San Bernardino	321	675	50	552	73	175	28	0	147	368	35	150	183
Mill Creek	Redlands	247	518	35	235	248	590	0	485	105	263	35	130	98
Santa Ana River	Riverside	44	90	15	0	75	180	0	165	15	38	15	0	23
Temescal Creek	Corona	137	288	0	199	89	214	0	182	32	80	30	0	50
Bautista Creek	San Jacinto	45	95	0	51	44	105	0	92	13	32	10	0	22
San Jacinto River	Perris	6	13	0	0	13	31	0	0	31	78	0	66	12
Santa Ana River	Santa Ana	76	151	0	0	151	372	0	322	50	145	10	100	35
Subtotal		1,310	2,740	135	1,672	933	2,235	188	1,433	614	1,556	310	586	660
Orange County Streams														
Laguna Creek	Laguna Beach	8	16	0	0	16	32	0	28	4	10	7	0	3
San Luis Rey River Basin														
San Luis Rey River	Oceanside	184	415	0	385	30	70	0	0	70	120	40	0	80
Buena Vista Creek	Vista	13	45	0	0	45	105	40	0	65	110	0	75	35
San Marcos Creek	Leucadia	110	370	0	170	200	470	70	250	150	255	30	150	75
Subtotal		307	830	0	555	275	645	110	250	285	485	70	225	190
San Dieguito River Basin														
San Dieguito River	Del Mar	111	250	0	135	115	270	0	195	75	125	45	0	80
San Diego River Basin														
San Diego River	San Diego	634	1,271	0	1,170	101	203	70	0	133	263	95	90	78
San Diego River	El Cajon	433	864	0	800	64	128	45	0	83	166	60	0	106
Subtotal		1,067	2,135	0	1,970	165	331	115	0	216	429	155	90	184
Sweetwater River Basin														
Las Chollas	San Diego	50	100	20	0	80	160	35	0	125	250	70	110	70
Sweetwater River	National City	88	198	0	188	10	24	0	0	24	41	0	26	15
Sweetwater River	Chula Vista	61	138	0	130	8	19	0	0	19	32	0	21	11
Subtotal		199	436	20	318	98	203	35	0	168	323	70	157	96
Otay-Tijuana Rivers Basin														
Otay-Tijuana Rivers	Imperial Beach	85	191	14	115	62	147	20	0	127	216	72	46	98
Total South Coastal Subregion		7,617	14,679	1,441	7,593	5,645	11,642	1,903	5,484	4,255	8,224	1,877	2,744	3,603

1/ Figures shown in Column 3 are from Column 7 of Table 9 and are also shown in Column 3 of Table 9a.
2/ Figures in Column 4 are from Column 4 of Table 9a.
3/ Column 7 = Column 4 - Column 5 - Column 6.
4/ Column 11 = Column 8 - Column 9 - Column 10.
5/ Column 15 = Column 12 - Column 13 - Column 14.

TABLE 10

SOUTH COASTAL SUBREGION OF THE CALIFORNIA REGION

Estimated Costs of Future Flood Control Program
- 1966 to 1980 -
($1,000)

Study area	Levees & channels				Flood control reservoirs				Non-structural measures			
	Federal		Non-Federal		Federal		Non-Federal		Federal		Non-Federal	
	Installation costs	Annual OM&R costs	Installation costs	Annual OM&R costs	Installation costs	Annual OM&R costs	Installation costs	Annual OM&R costs	Installation costs	Annual OM&R costs	Installation costs	Annual OM&R costs
1	2	3	4	5	6	7	8	9	10	11	12	13
Ventura River Basin	4,500	0	1,500	20	0	0	0	0	110	20	460	29
Santa Clara River Basin	25,800	0	8,900	104	0	0	0	0	720	93	5,250	143
Calleguas Creek Basin	9,400	0	3,100	35	0	0	0	0	90	13	2,500	37
Malibu Coastal Streams	0	0	0	0	0	0	0	0	70	11	450	26
Santa Monica Bay Streams	3,500	0	1,000	14	0	0	0	0	110	8	6,850	52
Los Angeles River Basin	3,300	0	1,100	13	0	0	0	0	390	107	5,440	480
San Gabriel River Basin	15,000	0	5,000	60	0	0	0	0	580	75	4,060	90
Santa Ana River Basin	97,670	0	31,890	379	69,590	0	15,650	269	680	101	9,130	238
Orange County Streams	0	0	0	0	0	0	0	0	140	37	260	53
Santa Margarita River Basin	0	0	0	0	0	0	0	0	220	39	1,490	75
San Luis Rey River Basin	10,700	0	3,600	44	0	0	0	0	130	21	290	46
San Diegu[illegible] Basin	6,450	0	1,270	70	5,750	0	500	24	100	15	420	33
San D[illegible] Basin	24,100	0	7,000	90	420	0	360	1	130	20	800	47
Swe[illegible] Basin	4,900	0	4,300	30	0	0	0	0	110	17	510	39
Otay-Tijuana Rivers Basin	10,350	0	2,250	17	0	0	0	0	160	24	520	53
Total South Coastal Subregion	215,670	0	70,910	876	75,760	0	16,510	294	3,740	601	38,430	1,441

June 1971

TABLE 10a

SOUTH COASTAL SUBREGION OF THE CALIFORNIA REGION

Estimated Costs of Future Flood Control Program
- 1981 to 2020 -
($1,000)

Study area	Levees & channels				Flood control reservoirs				Non-structural measures			
	Federal		Non-Federal		Federal		Non-Federal		Federal		Non-Federal	
	Installation costs	Annual OM&R costs	Installation costs	Annual OM&R costs	Installation costs	Annual OM&R costs	Installation costs	Annual OM&R costs	Installation costs	Annual OM&R costs	Installation costs	Annual OM&R costs
1	2	3	4	5	6	7	8	9	10	11	12	13
Ventura River Basin	6,800	0	2,200	25	0	0	0	0	150	39	620	57
Santa Clara River Basin	11,900	0	3,660	68	2,070	0	300	7	1,030	191	3,050	298
Calleguas Creek Basin	9,500	0	3,200	40	7,500	0	2,500	30	200	32	2,850	75
Malibu Coastal Streams	1,500	0	500	6	4,230	0	450	16	160	28	370	59
Santa Monica Bay Streams	3,700	0	1,200	15	0	0	0	0	200	20	10,000	91
Los Angeles River Basin	9,500	0	3,100	40	0	0	0	0	600	167	6,880	673
San Gabriel River Basin	7,070	0	1,900	31	24,460	0	740	91	710	138	4,580	177
Santa Ana River Basin	89,500	0	29,280	401	65,900	0	11,310	260	1,280	214	14,150	477
Orange County Streams	14,550	0	4,200	55	6,850	0	2,260	24	260	74	540	115
Santa Margarita River Basin	340	0	10	8	1,870	0	630	8	500	89	1,120	174
San Luis Rey River Basin	7,330	0	1,600	76	5,450	0	600	22	350	53	2,830	126
San Dieguito River Basin	3,800	0	1,200	15	800	0	6,800	25	230	38	1,030	82
San Diego River Basin	0	0	0	0	1,930	0	860	10	300	51	2,360	116
Sweetwater River Basin	0	0	1,600	15	0	0	0	0	250	44	1,040	92
Otay-Tijuana Rivers Basin	0	0	0	0	0	0	0	0	350	60	980	128
Total South Coastal Subregion	165,490	0	53,650	795	121,060	0	26,450	493	6,570	1,238	52,400	2,740

June 1971

TABLE 10b

SOUTH COASTAL SUBREGION OF THE CALIFORNIA REGION

Estimated Costs of Future Flood Control Program
- 2001 to 2020 -
($1,000)

Study area	Levees & channels				Flood control reservoirs				Non-structural measures			
	Federal		Non-Federal		Federal		Non-Federal		Federal		Non-Federal	
	Installation costs	Annual OM&R costs	Installation costs	Annual OM&R costs	Installation costs	Annual OM&R costs	Installation costs	Annual OM&R costs	Installation costs	Annual OM&R costs	Installation costs	Annual OM&R costs
1	2	3	4	5	6	7	8	9	10	11	12	13
Ventura River Basin	1,300	0	500	5	0	0	0	0	100	43	100	52
Santa Clara River Basin	4,000	0	1,000	15	10,500	0	3,500	36	620	161	4,740	208
Calleguas Creek Basin	16,000	0	5,000	60	0	0	0	0	150	26	5,530	72
Malibu Coastal Streams	1,100	0	400	5	0	0	0	0	110	20	670	42
Santa Monica Bay Streams	2,400	0	800	10	0	0	0	0	140	15	6,800	63
Los Angeles River Basin	4,300	0	1,400	17	0	0	0	0	330	162	2,100	695
San Gabriel River Basin	3,800	0	1,200	15	0	0	0	0	390	128	3,600	119
Santa Ana River Basin	66,200	0	21,900	267	0	0	0	0	940	178	22,440	407
Orange County Streams	19,450	0	5,700	70	0	0	0	0	180	81	840	109
Santa Margarita River Basin	3,100	0	1,000	12	0	0	0	0	320	68	3,040	125
San Luis Rey River Basin	1,000	0	500	5	0	0	0	0	230	39	3,410	97
San Dieguito River Basin	1,000	0	500	3	2,930	0	180	13	150	30	2,100	63
San Diego River Basin	1,000	0	500	3	0	0	0	0	210	43	3,650	100
Sweetwater River Basin	2,200	0	2,000	19	2,230	0	300	9	160	39	1,600	75
Otay-Tijuana Rivers Basin	0	0	0	0	13,040	0	1,860	50	230	51	1,700	102
Total South Coastal Subregion	126,850	0	42,400	506	28,700	0	5,840	108	4,260	1,084	62,320	2,329

June 1971

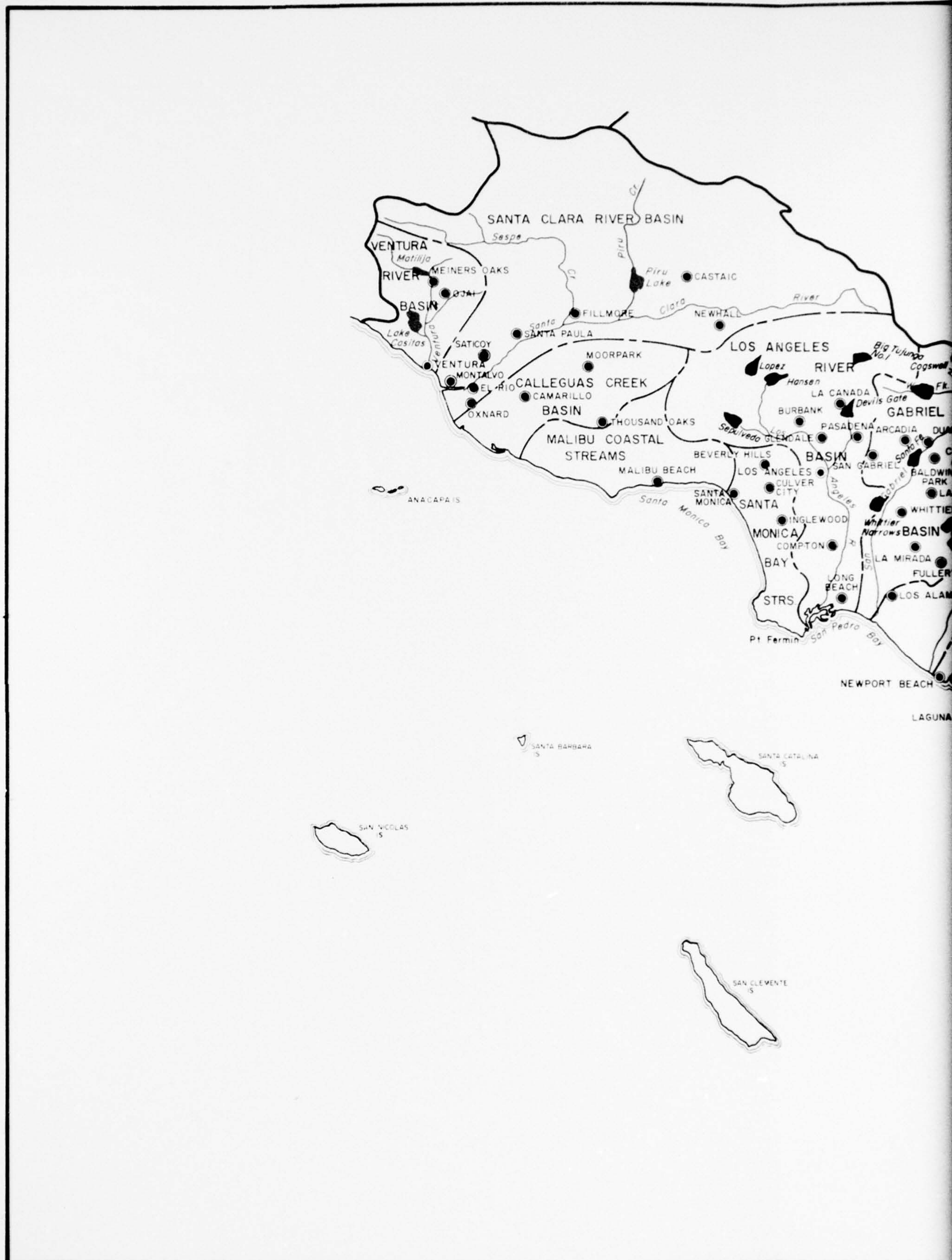
TABLE 11

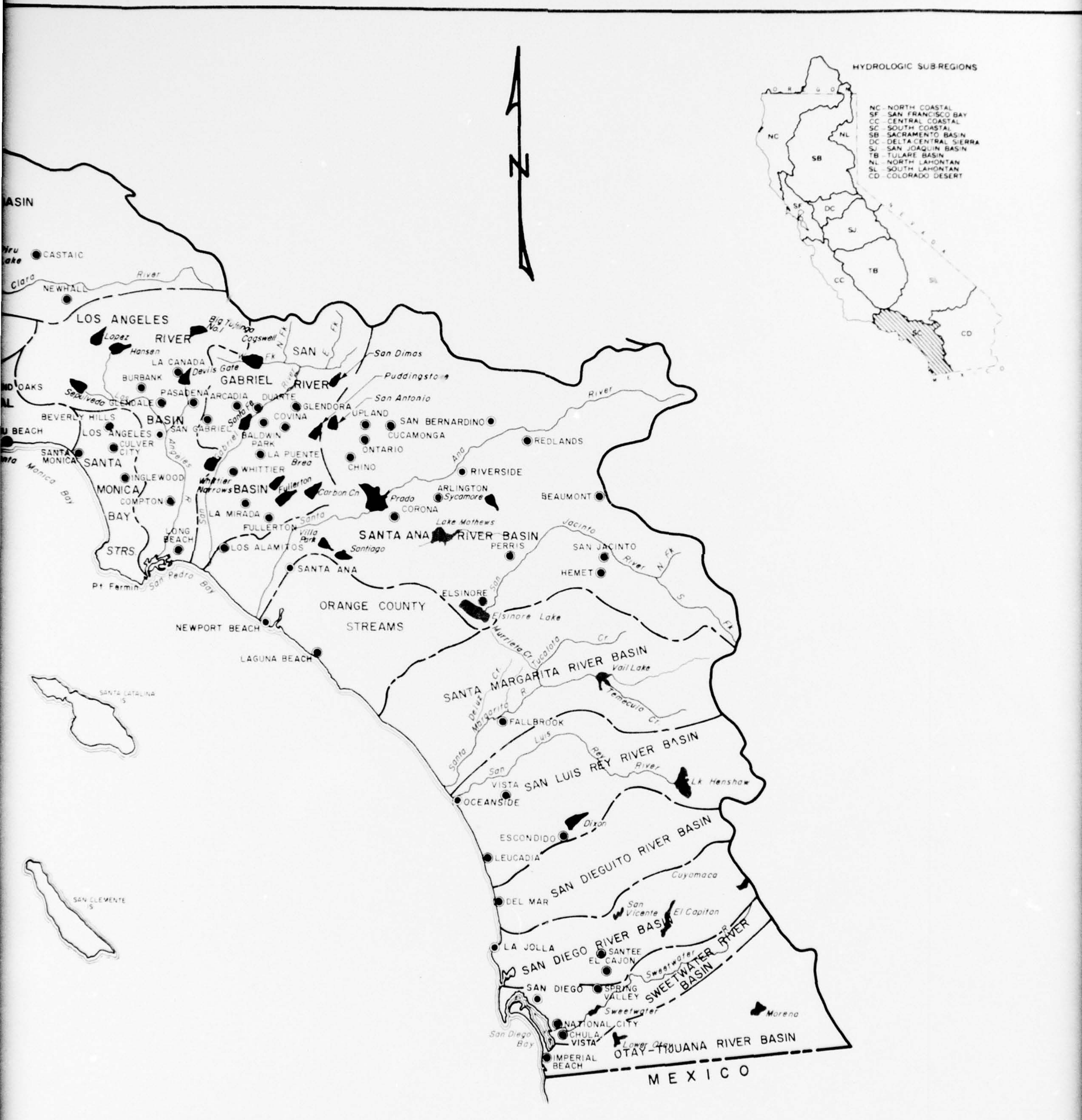
SOUTH COASTAL SUBREGION OF THE CALIFORNIA REGION

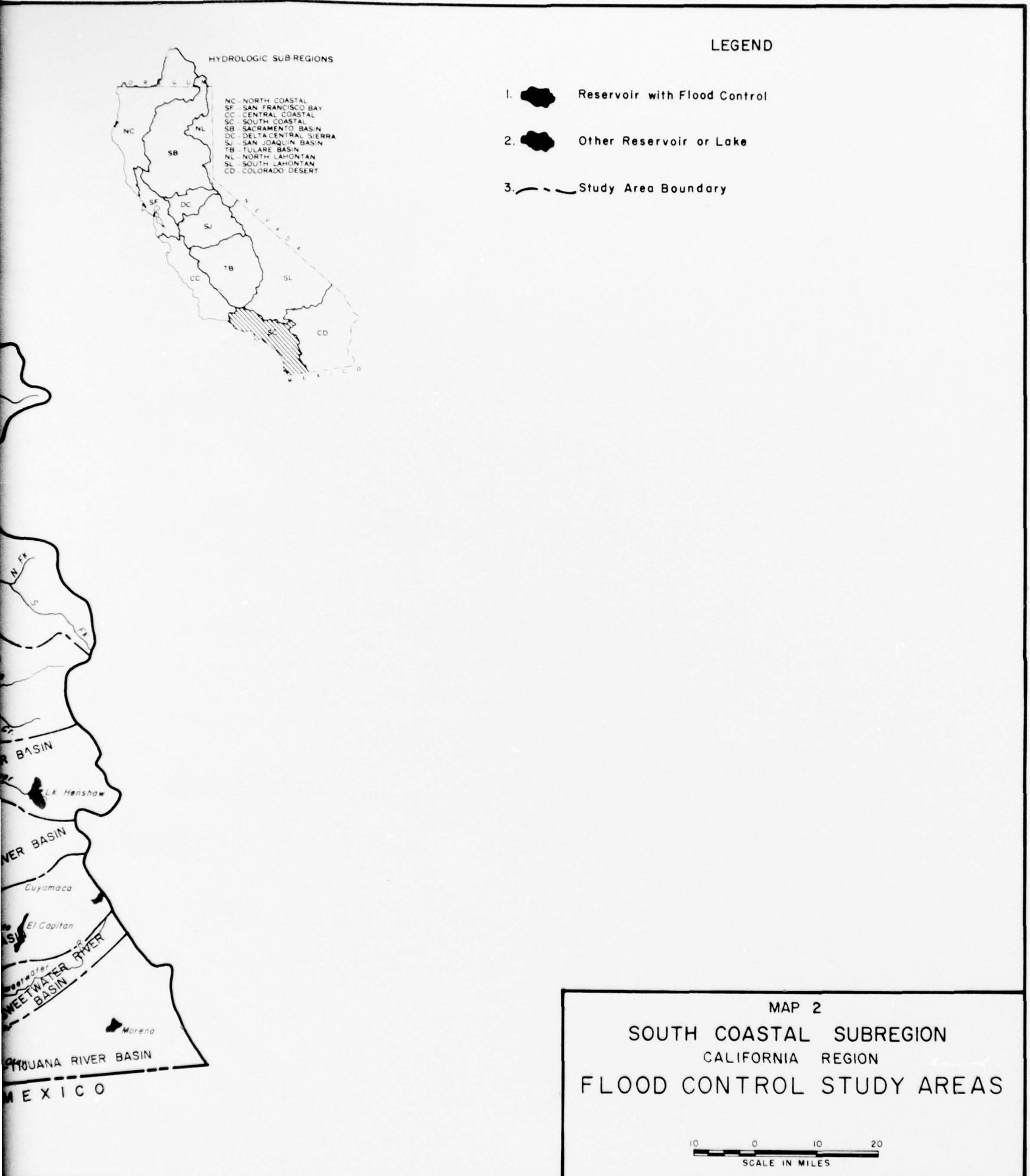
Flow Data at Selected Locations
(Flows in 1,000 cfs)

Study area/ stream	Location	Non-damaging flow 1/	Maximum flood of record: Date	Maximum flood of record: Flow: At time of occurrence	Maximum flood of record: Flow: Existing (1965) project conditions	Maximum flood of record: Flow: Future project conditions 2/: 1980	2000	2020	Flow of standard project flood: Existing (1965) project conditions	Flow of standard project flood: Future project conditions 2/: 1980	2000	2020	Flow of 100-year frequency flood: Existing (1965) project conditions	Flow of 100-year frequency flood: Future project conditions 2/: 1980	2000	2020
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Santa Clara River Basin																
Santa Clara River	Near Saticoy	50	Jan69	165	165	165	165	145	250	250	250	225	175	175	175	155
Sespe Creek	Near Fillmore	3/	Jan69	60	60	60	60	3/	109	109	109	3/	75	75	75	3/
Santa Ana River Basin																
Santa Ana River	At Santa Ana	5	Mar38	46	50	14	15	15	155	43	44	44	54	15	16	16
Santa Margarita River Basin																
Santa Margarita River	Near Fallbrook	10	Feb27	33	35	3	3	4	134	9	9	10	76	6	6	7
San Dieguito River Basin																
San Dieguito River	At Lake Hodges	3	Jan16	72	24	24	2	2	67	67	5	5	47	47	4	4

1/ Under 1965 project conditions.
2/ Flows as modified by projects likely to be in a future flood control program by the years 1980, 2000, and 2020.
3/ Less than 1,000 cfs.

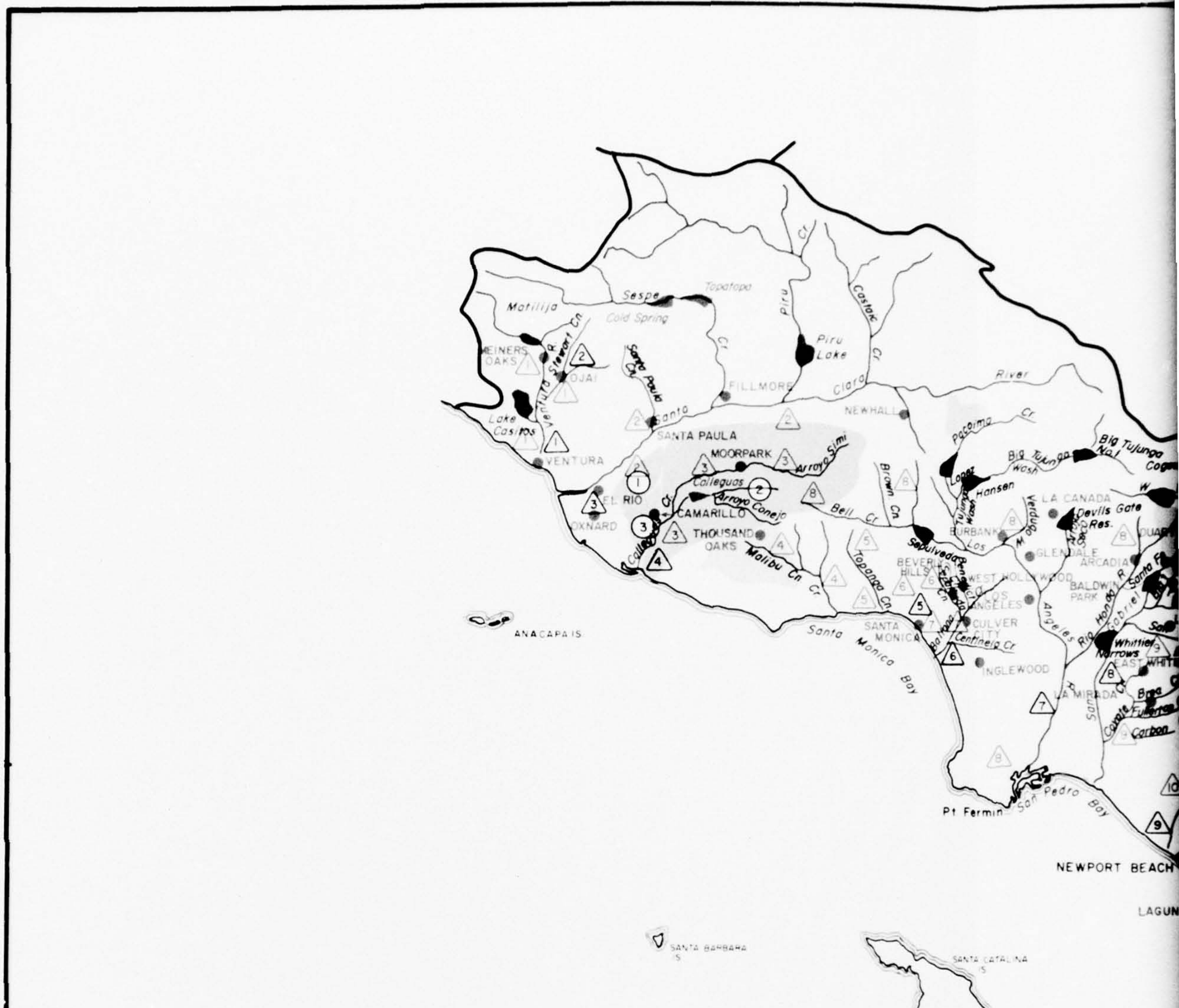

SANTA CLARA RIVER BASIN
VENTURA RIVER BASIN
Matilija
MEINERS OAKS
OJAI
Lake Casitas
Ventura
Sespe
Piru Cr
Piru Lake
CASTAIC
FILLMORE
Santa Clara River
NEWHALL
SANTA PAULA
SATICOY
VENTURA
MONTALVO
EL RIO
OXNARD
MOORPARK
CALLEGUAS CREEK BASIN
CAMARILLO
THOUSAND OAKS
MALIBU COASTAL STREAMS
MALIBU BEACH
LOS ANGELES RIVER BASIN
Big Tujunga No.1
Lopez
Hansen
Cogswell
LA CANADA
Devils Gate
BURBANK
Sepulveda
GLENDALE
PASADENA
ARCADIA
GABRIEL
BEVERLY HILLS
LOS ANGELES
SAN GABRIEL
Santa Fe
BALDWIN PARK
CULVER CITY
SANTA MONICA
SANTA MONICA BAY STRS
Santa Monica Bay
INGLEWOOD
COMPTON
Whittier Narrows
WHITTIER
BASIN
LA MIRADA
LONG BEACH
LOS ALAM
Pt Fermin
San Pedro Bay
NEWPORT BEACH
LAGUNA
ANACAPA IS.
SANTA BARBARA IS
SANTA CATALINA IS
SAN NICOLAS IS
SAN CLEMENTE IS


HYDROLOGIC SUB-REGIONS
NC - NORTH COASTAL
SF - SAN FRANCISCO BAY
CC - CENTRAL COASTAL
SC - SOUTH COASTAL
SB - SACRAMENTO BASIN
DC - DELTA-CENTRAL SIERRA
SJ - SAN JOAQUIN BASIN
TB - TULARE BASIN
NL - NORTH LAHONTAN
SL - SOUTH LAHONTAN
CD - COLORADO DESERT
N
CASTAIC
NEWHALL
LOS ANGELES RIVER BASIN
SAN GABRIEL RIVER BASIN
SANTA MONICA BAY STRS
SANTA ANA RIVER BASIN
ORANGE COUNTY STREAMS
SANTA MARGARITA RIVER BASIN
SAN LUIS REY RIVER BASIN
SAN DIEGUITO RIVER BASIN
SAN DIEGO RIVER BASIN
SWEETWATER RIVER BASIN
OTAY-TIJUANA RIVER BASIN
MEXICO
Lopez
Hansen
Big Tujunga
Cogswell
Devils Gate
San Dimas
Puddingstone
San Antonio
Sepulveda
Santa Fe
Whittier Narrows
Brea
Fullerton
Carbon Cn
Prado
Sycamore
Lake Mathews
Villa Park
Santiago
Elsinore Lake
Vail Lake
Lk Henshaw
Dixon
Cuyamaca
San Vicente
El Capitan
Sweetwater
Lower Otay
Morena
BURBANK
LA CANADA
PASADENA
GLENDALE
ARCADIA
DUARTE
GLENDORA
UPLAND
SAN BERNARDINO
CUCAMONGA
REDLANDS
ONTARIO
CHINO
RIVERSIDE
BEVERLY HILLS
LOS ANGELES
CULVER CITY
SANTA MONICA
SAN GABRIEL
BALDWIN PARK
COVINA
LA PUENTE
WHITTIER
INGLEWOOD
COMPTON
LA MIRADA
FULLERTON
LONG BEACH
LOS ALAMITOS
ARLINGTON
CORONA
BEAUMONT
PERRIS
SAN JACINTO
HEMET
SANTA ANA
ELSINORE
NEWPORT BEACH
LAGUNA BEACH
Pt. Fermin
San Pedro Bay
Santa Monica Bay
SANTA CATALINA IS
SAN CLEMENTE IS
FALLBROOK
VISTA
OCEANSIDE
ESCONDIDO
LEUCADIA
DEL MAR
LA JOLLA
SANTEE
EL CAJON
SAN DIEGO
SPRING VALLEY
NATIONAL CITY
CHULA VISTA
IMPERIAL BEACH
San Diego Bay
Santa Clara River
Santa Ana River
San Jacinto River
Murrieta Cr
Tucalota Cr
Temecula Cr
Santa Margarita R
San Luis Rey River


LEGEND
1. Reservoir with Flood Control
2. Other Reservoir or Lake
3. Study Area Boundary
HYDROLOGIC SUB-REGIONS
NC - NORTH COASTAL
SF - SAN FRANCISCO BAY
CC - CENTRAL COASTAL
SC - SOUTH COASTAL
SB - SACRAMENTO BASIN
DC - DELTA CENTRAL SIERRA
SJ - SAN JOAQUIN BASIN
TB - TULARE BASIN
NL - NORTH LAHONTAN
SL - SOUTH LAHONTAN
CD - COLORADO DESERT
Lk Henshaw
Cuyamaca
El Capitan
SWEETWATER RIVER BASIN
Morena
TIJUANA RIVER BASIN
MEXICO
MAP 2
SOUTH COASTAL SUBREGION
CALIFORNIA REGION
FLOOD CONTROL STUDY AREAS
10 0 10 20
SCALE IN MILES

2

3



Motilija
Sespe
Topatopa
Cold Spring
Piru
Piru Lake
Castaic
MEINERS OAKS
OJAI
FILLMORE
Clara
River
NEWHALL
Lake Casitas
Santa
SANTA PAULA
Pacoima
Big Tujunga
VENTURA
MOORPARK
Arroyo Simi
Calleguas
Hansen
EL RIO
OXNARD
CAMARILLO
Arroyo Conejo
Bell Cr
Brown Cn
LA CANADA
Devils Gate Res.
THOUSAND OAKS
Malibu Cn Cr
Topanga Cn
Sepulveda
BURBANK
GLENDALE
ARCADIA
BEVERLY HILLS
WEST HOLLYWOOD
BALDWIN PARK
LOS ANGELES
SANTA MONICA
CULVER CITY
Centinela Cr
ANACAPA IS.
Santa Monica Bay
INGLEWOOD
Whittier Narrows
LA MIRADA
Carbon
Pt Fermin
San Pedro Bay
NEWPORT BEACH
SANTA BARBARA IS.
SANTA CATALINA IS.
SAN NICOLAS IS.
SAN CLEMENTE IS.


HYDROLOGIC SUB-REGIONS
NC - NORTH COASTAL
SF - SAN FRANCISCO BAY
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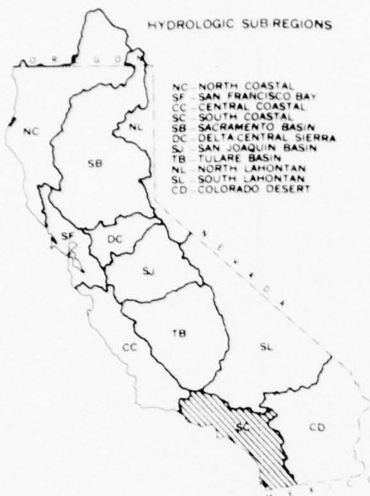
N
Piru Lake
NEWHALL
LA CANADA
BURBANK
GLENDALE
ARCADIA
DUARTE
BEVERLY HILLS
WEST HOLLYWOOD
LOS ANGELES
BALDWIN PARK
GLENDORA
COVINA
UPLAND
ONTARIO
CHINO
LA PUENTE
SANTA MONICA
CULVER CITY
INGLEWOOD
EAST WHITTIER
LA MIRADA
Santa Monica Bay
Pt Fermin
San Pedro Bay
NEWPORT BEACH
LAGUNA BEACH
SANTA ANA
CORONA
RIVERSIDE
SAN BERNARDINO
REDLANDS
SAN JACINTO
Prado
Lake Mathews
Elsinore Lake
Vail Lake
Villa Park
Santiago
Sepulveda
Hansen
Lopez
Devils Gate Res.
Big Tujunga No. 1
Cogswell
Whittier Narrows
Brea
Fullerton
Carbon Cn.
San Antonio
Sycamore
Salt Cr.
San Juan Cr.
Santa Margarita R.
De Luz
San Luis Rey River
Lk. Henshaw
OCEANSIDE
VISTA
Dixon
Lk. Hodges
LEUCADIA
DEL MAR
LA JOLLA
EL CAJON
SAN DIEGO
San Diego Bay
Cuyamaca
San Vicente
El Capitan
Sweetwater
Barrett Lk
Morena
Lower Otay
IMPERIAL BEACH
MEXICO
SANTA CATALINA IS
SAN CLEMENTE IS



LEGEND

1. Existing Projects (in Operation 1965)
(See Table 6 & 7)

Reservoirs with Flood Control

1. Devils Gate
2. Big Tujunga No. 1
3. Hansen
4. Sepulveda
5. Lopez
6. Puddingstone
7. San Dimas
8. Cogswell
9. Santa Fe
10. Whittier Narrows
11. Brea
12. Carbon Canyon
13. Fullerton
14. San Antonio
15. Prado
16. Sycamore
17. Santiago
18. Villa Park
19. Dixon

Other Reservoirs or Lakes

Levee & Channel Projects

1. Ventura R
2. Stewart Cn
3. Santa Clara R
4. Calleguas Cr & Tribs
5. Kenter Cn
6. Ballona Cr & Tribs
7. Los Angeles R Basin
8. San Gabriel R Basin
9. Santa Ana R Basin
10. Orange County Streams
11. Santa Margarita R Basin
12. San Luis Rey R Basin
13. San Dieguito R Basin
14. San Diego R Basin

Watershed Projects

1. Beardsley
2. Calleguas Cr
3. Revolon
4. Buena Vista
5. Escondido

2. Potential Future Flood Control Program
A (1966-1980), A_1 (Constructed or Funded for Construction as of FY 1970), B (1981-2000), C (2001-2020). (See Tables 6 & 7)

Reservoirs with Flood Control

1. Topatopa (C)
2. Cold Springs (C)
3. Calleguas (B)
4. Prado (A)
5. Salt Cr (B)
6. San Juan Cr (B)
7. De Luz (B)
8. Monserate (B)
9. San Dieguito (B)

Levee & Channel Projects

1. Ventura R (A,B,C)
2. Santa Clara R (A,B,C)
3. Calleguas Cr (A,B,C)
4. Malibu Cr (B,C)
5. Topanga Cn Cr (B,C)
6. Kenter Cn Cr (A,B)
7. Ballona Cr (B,C)
8. Los Angeles R Basin (A,A_1,B,C)
9. San Gabriel R Basin (A,A_1,B,C)
10. Santa Ana R Basin (A,B,C)
11. Orange County Streams (B,C)
12. San Margarita R Basin (B,C)
13. San Luis Rey R Basin (A,B,C)
14. San Dieguito R Basin (A,B,C)
15. San Diego R Basin (A,B)
16. Sweetwater R Basin (A,B,C)
17. Otay-Tijuana R Basin (A,C)

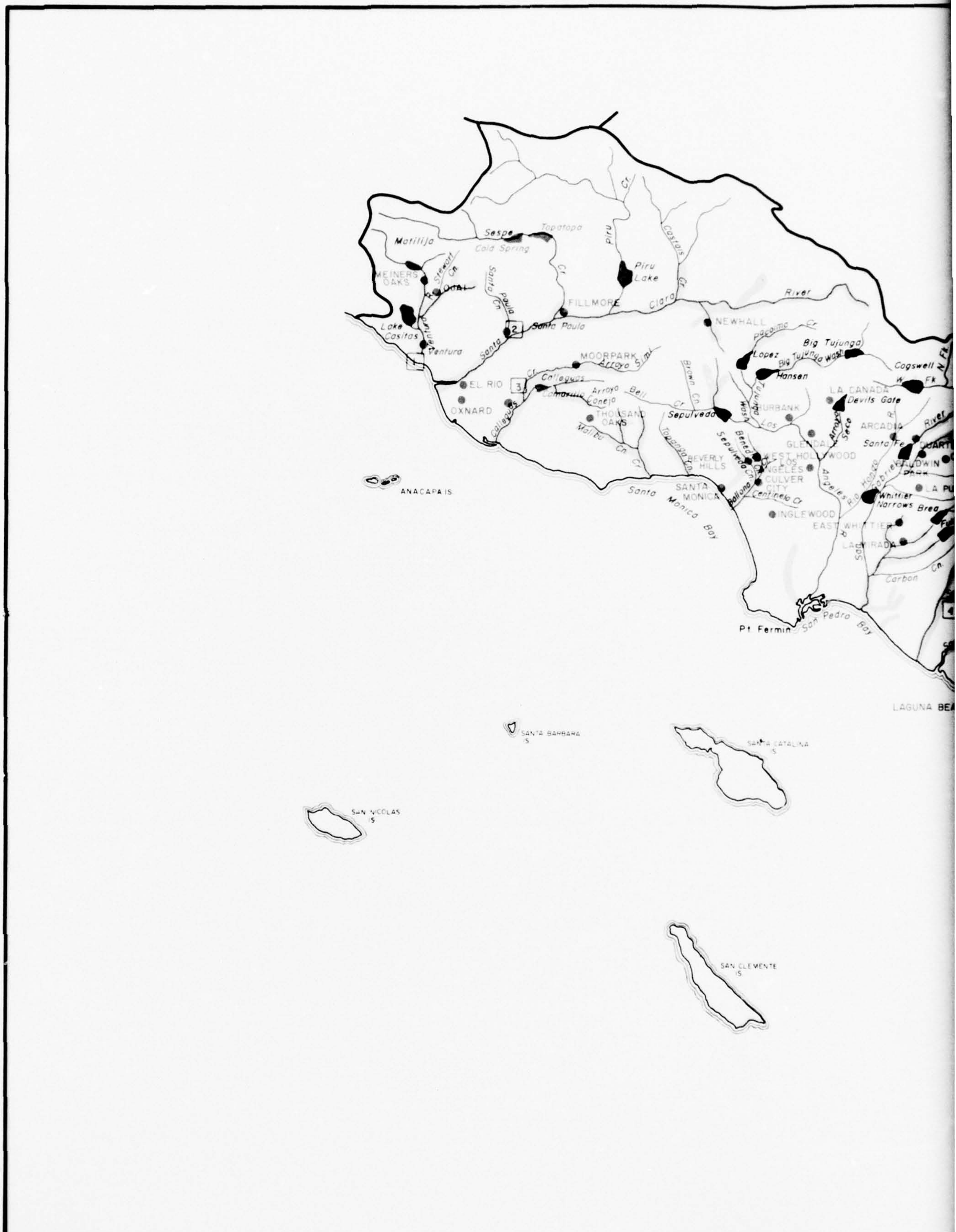
Watershed Projects

Locations of non-structural floodplain management measures

MAP 3
SOUTH COASTAL SUBREGION
CALIFORNIA REGION
FLOOD CONTROL PLAN

10 0 10 20
SCALE IN MILES

3



Matilija
Sespe
Topatopa
Cold Spring
Piru Lake
MEINERS OAKS
OJAI
Lake Casitas
Ventura
FILLMORE
Santa Paula
River
NEWHALL
MOORPARK
Arroyo Simi
EL RIO
OXNARD
Calleguas
Conejo
THOUSAND OAKS
Malibu
Lopez
Big Tujunga
Hansen
Cogswell
LA CANADA
Devils Gate
Sepulveda
BURBANK
ARCADIA
Santa Fe
GLENDALE
WEST HOLLYWOOD
BEVERLY HILLS
LOS ANGELES
CULVER CITY
SANTA MONICA
Ballona
Centinela Cr
INGLEWOOD
EAST WHITTIER
Whittier Narrows
Brea
LA MIRADA
Carbon
Santa Monica Bay
ANACAPA IS.
Pt. Fermin
San Pedro Bay
LAGUNA BEACH
SANTA BARBARA IS
SANTA CATALINA IS
SAN NICOLAS IS
SAN CLEMENTE IS


HYDROLOGIC SUB REGIONS
NC NORTH COASTAL
SF SAN FRANCISCO BAY
CC CENTRAL COASTAL
SC SOUTH COASTAL
SB SACRAMENTO BASIN
DC DELTA-CENTRAL SIERRA
SJ SAN JOAQUIN BASIN
TB TULARE BASIN
NL NORTH LAHONTAN
SL SOUTH LAHONTAN
CD COLORADO DESERT
N
1.
2.
3.
4.
5.
6.
Big Tujunga
Lopez
Hansen
Cogswell
LA CANADA
Devils Gate
BURBANK
San Dimas
ARCADIA
GLENDALE
Santa Fe
GLENDORA
DUARTE
San Antonio
UPLAND
BALDWIN PARK
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CULVER CITY
LA PUENTE
CHINO
Whittier Narrows
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EAST WHITTIER
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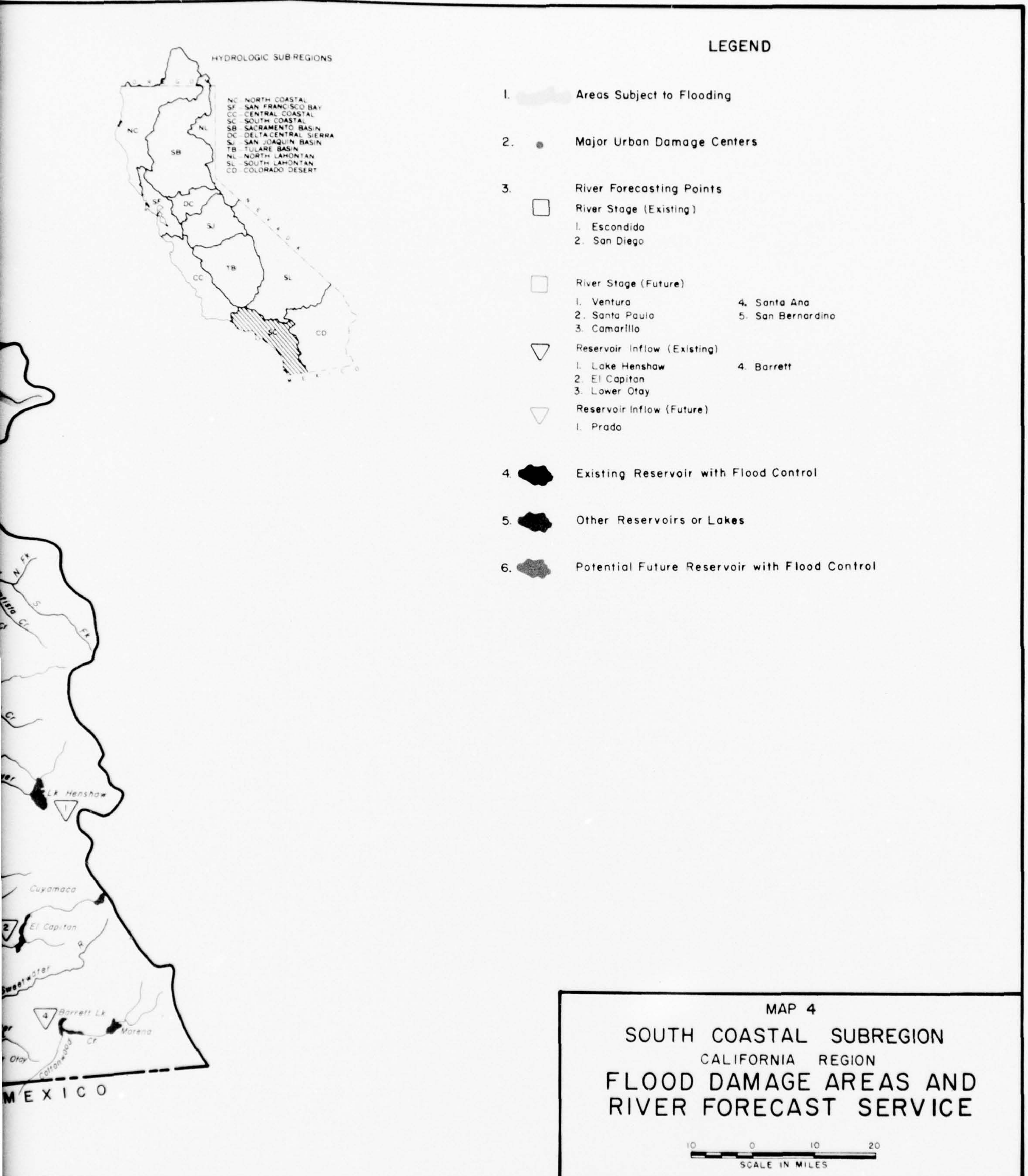
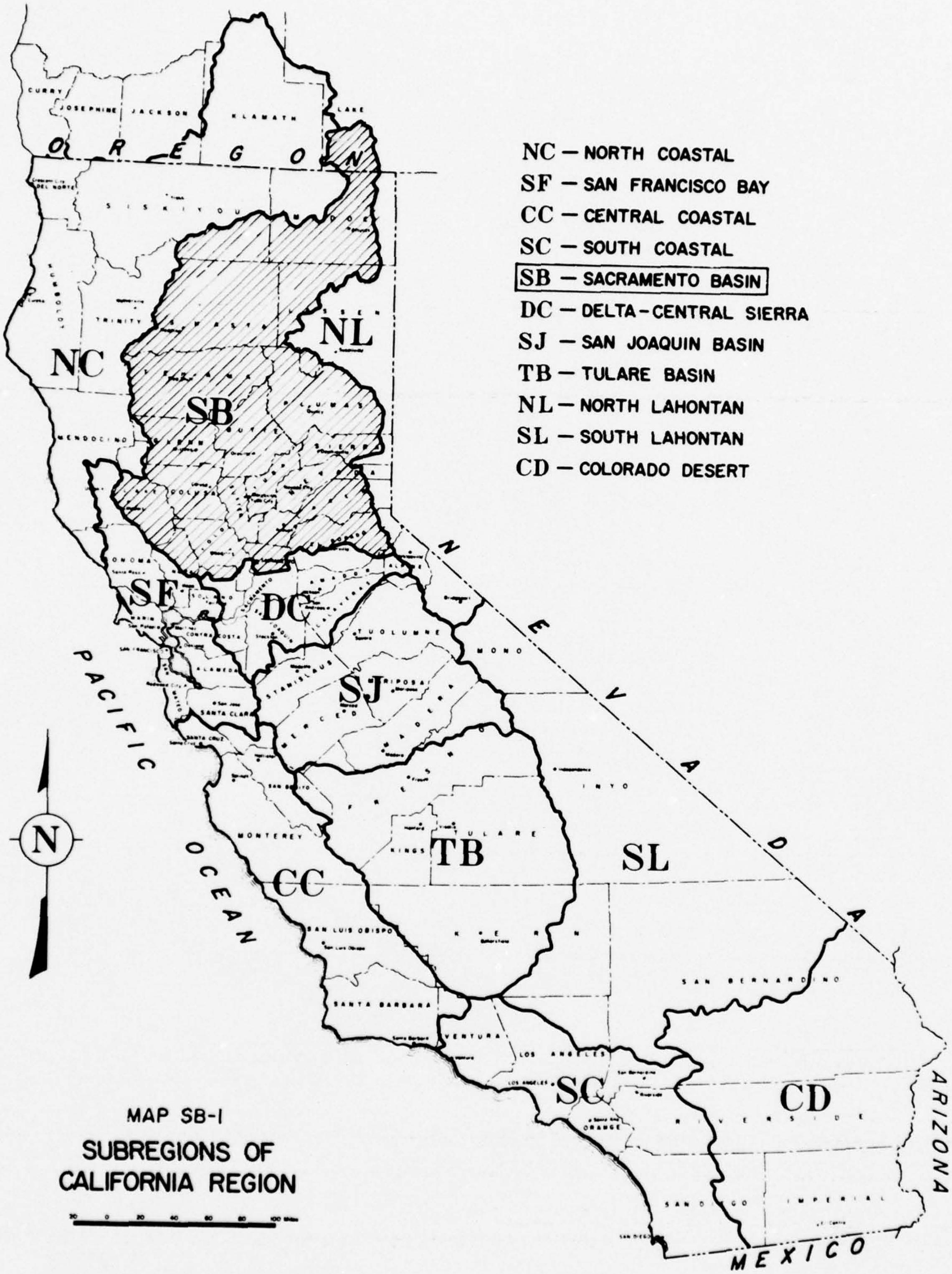
REDLANDS
RIVERSIDE
San Bernardino
Mill Cr
Sycamore
Lake Mathews
PERRIS
SAN JACINTO
Elsinore Lake
Salt Cr
Murrieta Cr
Tucalota
Vail Lake
Temecula Cr
LAGUNA BEACH
San Juan Cr.
Trabuco
SANTA CATALINA IS.
Santa Margarita R
De Luz
Monserate
Lk. Henshaw
San Luis Rey River
OCEANSIDE
Buena Vista Cr.
VISTA
Dixon
San Marcos Cr
LEUCADIA
Escondido
Lk Hodges
San Dieguito
Cuyamaca
DEL MAR
Los Penasquitos Cr
San Vicente
El Capitan
Rose Cr
San Diego R
EL CAJON
Sweetwater
SAN CLEMENTE IS
SAN DIEGO
Barrett Lk
Morena
San Diego Bay
NATIONAL CITY
CHULA VISTA
Lower Otay
Cottonwood Cr
IMPERIAL BEACH
MEXICO

2


LEGEND
1. Areas Subject to Flooding
2. Major Urban Damage Centers
3. River Forecasting Points
River Stage (Existing)
1. Escondido
2. San Diego
River Stage (Future)
1. Ventura
2. Santa Paula
3. Camarillo
4. Santa Ana
5. San Bernardino
Reservoir Inflow (Existing)
1. Lake Henshaw
2. El Capitan
3. Lower Otay
4. Barrett
Reservoir Inflow (Future)
1. Prado
4. Existing Reservoir with Flood Control
5. Other Reservoirs or Lakes
6. Potential Future Reservoir with Flood Control
HYDROLOGIC SUBREGIONS
NC NORTH COASTAL
SF SAN FRANCISCO BAY
CC CENTRAL COASTAL
SC SOUTH COASTAL
SB SACRAMENTO BASIN
DC DELTACENTRAL SIERRA
SJ SAN JOAQUIN BASIN
TB TULARE BASIN
NL NORTH LAHONTAN
SL SOUTH LAHONTAN
CD COLORADO DESERT
Lk Henshaw
Cuyamaca
El Capitan
Sweetwater
Barrett Lk
Morena
Otay
Cottonwood
Cr.
MEXICO
MAP 4
SOUTH COASTAL SUBREGION
CALIFORNIA REGION
FLOOD DAMAGE AREAS AND
RIVER FORECAST SERVICE
10 0 10 20
SCALE IN MILES

3

SACRAMENTO
BASIN
SUBREGION



MAP SB-1

SUBREGIONS OF CALIFORNIA REGION

SACRAMENTO BASIN SUBREGION

General

The Sacramento Basin Subregion (SB) is situated in northcentral California and southern Oregon and covers approximately the northern half of the Great Central Valley of California. It is bounded by the Sierra Nevada on the east, the Coast Ranges on the west, the Cascade Range and Trinity Mountains on the north, and the northern border of the Delta-Central Sierra Subregion near the city of Sacramento on the south. (See Map SB-1.) A portion of the watershed of Pit River, the most northern tributary of Sacramento River, lies outside the mountains delimiting the basin in the northeast, but drains through the crest of the Cascade Range into the Sacramento Basin proper. The subregion is about 280 miles long and 130 miles wide and comprises an area of 26,498 square miles in California and 717 square miles in Oregon.

The climate of the subregion is characterized by hot, dry summers and mild winters with relatively light precipitation in basin floor areas, and by warm, dry summers and cold winters with heavy rain and snow in the mountainous areas. Average annual precipitation varies with elevation, ranging from less than 10 inches on the basin floor to over 95 inches in the Sierra Nevada and Cascade Range. Temperatures on the valley floor normally range from winter lows near freezing to summer highs of about 110 degrees. In mountainous areas, winter temperatures average about 30 degrees, but occasionally fall below zero.

The subregion had an estimated total population of 1,089,000 in 1965. Agriculture is the dominant economic activity of the subregion and includes both crop and livestock production. Crop production shows a high degree of diversification with grain, deciduous and citrus fruits, and truck crops all being produced within the subregion. Livestock production is represented principally by the raising of beef and dairy cattle and sheep. Important economic functions subsidiary to agriculture include the packing and processing industry, the agricultural-service industry, and the farm equipment industry. The production of natural gas, clay, limestone, sand and gravel, and lumber and other forest products are also significant economic activities in the subregion. In the Sacramento area, military activities, Federal and State Government agencies and the aerospace industry comprise an important segment of the economy.

The Sacramento Basin Subregion is well provided with highways, airlines, railroads, and waterway transport facilities, including the Sacramento Deep Water Ship Channel. A highly developed Federal, State, and county highway and road system affords ready access to all parts of the basin and to adjoining areas.

The Sacramento River is the principal stream in the subregion. Its head waters near Mount Shasta rise to an elevation of 6,000 feet and descend

through a deep canyon to Shasta Lake where it is joined by the McCloud and Pit Rivers. From Shasta Lake, Sacramento River flows southward to the edge of the alluvial valley south of Red Bluff. From near Chico the river flows southward to Colusa, thence southeasterly in a leveed channel along an alluvial ridge flanked by overflow basins. An overflow basin to the west receives flow from several minor tributaries. Butte Basin, the overflow basin to the east, receives the flow of several minor tributaries, natural overflow from Sacramento River in the reach below Chico, and overflow from two weirs acting as safety valves for the Sacramento River levee project. Outflow from Butte Basin discharges through the Sutter Bypass and reenters the Sacramento River at the confluence of Feather River. At this point when Sacramento River flow exceeds about 70,000 cubic feet per second spill occurs over a weir into the leveed Yolo Bypass. Sacramento River is joined by the American River at City of Sacramento. Large flows from American River create backwater as far upstream as the confluence of Feather River reducing flow in the mainstem leveed channel between this point and a downstream overflow weir discharging into Yolo Bypass opposite the confluence of American River. This weir diverts combined American River backwater and Sacramento River flows in excess of about 85,000 cubic feet per second and hence out of the Sacramento Basin Subregion into the Delta-Central Sierra Subregion.

Additional information on the subregion can be found in Appendix II, "The Region."

For the investigation of present and future flood problems and the analysis of potential solutions, the subregion has been subdivided into the following study areas: Sacramento River Basin above Shasta Dam, Sacramento River-Shasta Dam to Sacramento, Redding Stream Group, Middle Sacramento River Tributaries-Eastside, Middle Sacramento River Tributaries-Westside, Stony Creek Basin, Colusa Basin and Tributary Streams, Butte Basin and Tributary Streams, Feather River Basin, Yuba River Basin, Bear River Basin, Coon Creek Stream Group, American River Basin, Cache Creek Basin, Putah Creek Basin, Morrison Creek Stream Group, and Project Bypass in Sacramento Basin. The principal streams in these areas are shown on Map 2.

History of Flooding

The Sacramento Basin Subregion, similar to other subregions in northern and central California, is periodically subject to widespread storms during the winter season, which extends from November through March. Winter storms account for about 80% of the annual precipitation of this area.

The subregion experiences two types of flood: 1) those that occur during the late fall and winter months, primarily as a result of prolonged general rainstorms in the mountain and valley floor areas; and

Although seriously eroded by extremely high stages caused by runoff from over 30 inches of precipitation on the basin during the preceding 12 days, the east levee on the Feather River midway between Yuba City and Sacramento still confined the river at noon on 23 December 1955. (Corps of Engineers Photos.)

PHOTO SB-Ia

Ten minutes later, however, the levee was breached and floodwaters began to flow.

PHOTO SB-Ib

Efforts to provide emergency reinforcement were useless.

PHOTO SB-Ic

After forty minutes, uncontrolled floodwaters poured through the breached levee to inundate about 25,000 acres of farmland and parts of two nearby towns. Damages were estimated at almost $7 million.

PHOTO SB-Id

2) those that occur during the spring and early summer months, primarily as a result of the melting of the winter snowpack in the high areas of the Sierra Nevada. The most significant type is the late fall and winter flood caused by general rainstorms. A description of the most noteworthy floods of the late 1800's and early 1900's is included in the regional section of the appendix. On a subregional basis, the flood of December 1955 was the most widespread and destructive since the floods of 1862 and 1867. Thirty-eight persons lost their lives during the December 1955 flood. Rainfall exceeded 30 inches during a period of 12 days over the headwaters of the Sacramento, Feather, and American Rivers. The resultant floodflows were substantially larger than the previous record flows of 1950. Although the Sacramento River was confined within its levees, overflow occurred at all of the relief weirs along the river (which are a part of the Sacramento River Flood Control Project), and flooding occurred within the project floodways and natural storage basins. Levees on Feather River failed south of the Marysville-Yuba City area flooding most of Yuba City and portions of other towns and suburban developments. Over 80,000 acres of agriculture lands were inundated. See Photos SB-I, SB-II and SB-III. Agricultural, public facility, and residential damage comprised nearly 90% of the total flood damage. About 50,000 people evacuated their homes for periods ranging from a few days to three months. Large evacuations occurred from Sutter and Yuba Counties. About 10,000 people were forced to flee their homes due to the Yuba City levee failure and the threat of flooding forced the evacuation of about 18,000 people from Marysville and vicinity. A levee failure downstream of Yuba-City near Nicolaus also caused widespread flooding and damages. Subregion-wide, about 263,000 acres were inundated principally by the Feather, Bear, and Sacramento Rivers and flood damages exceeded $65 million. Flood fighting and cleanup costs under the various Federal programs exceeded $4 million.

The second most destructive flood in the subregion on a dollar-damage basis was the flood of December 1964-January 1965. Photo SB-III shows result of record flow on Thomes Creek. It is significant to note that damages during this flood would have exceeded those of 1955 if it were not for improvements made in the flood control system in the intervening nine years. Damages from these and other significant recent floods in the subregion are tabulated on page SB-4 and shown in more detail in Tables 1 and 2.

Flood season (year)	Flood damage 1/ ($1,000)					
	Forest & range resources & facilities	Agricultural & land	Residential & commercial	Industrial & utility	Public facilities	Total
1950-1951	2,375	1,338	3,983	3,059 2/		10,755
1955-1956	4,536	23,994	14,486	5,159	17,482	65,657
1957-1958	524	5,341	977	187	2,759	9,788
1962-1963	978	1,177	267	426	3,233	6,081
1964-1965	4,531	7,559	1,533	3,913	21,562	39,098
1966-1967	0	1,780	44	7	58	1,889

1/ Based on prices and project and economic conditions at time of occurrence of flood.

2/ Total damages - industrial and utility, and public facilities.

Peak flows of maximum floods of record, 100-year floods, and standard project floods for selected stations in the subregion are shown on Table 11.

Present Status of Flood Control Improvements

The existing flood control improvements within the subregion include a variety of measures to reduce flood damages. (See Map 3.) They include flood forecasting, flood control reservoirs, floodwater retardation structures, levees and channels, tributary watershed treatment, and flood plain information studies. Existing measures, which are described in more detail in following paragraphs, provide flood protection to 50% of the area subject to flooding. The measures are located principally along the main river channels in the Sacramento Valley. Very little of the tributary area has flood protection works of any kind. Many of the tributary flood plains are frequently inundated, and sustain a great deal of damage due mainly to high crop values. In other areas, land is not used to its highest capability for fear of flood damage. With a few exceptions, the degree of protection provided by existing flood control measures varies from 100-year to standard project flood protection in urban areas, and from 10- to 50-year flood protection in agricultural areas.

Yuba City, December 1955. (Corps of Engineers Photo.)

PHOTO SB-II

Paskenta Bridge destroyed by record Thomes Creek floodflows, December 1964. (Tehama County Photo.)

PHOTO SB-III

The Federal-State River Forecast Center Sacramento prepares and distributes river and flood forecasts. These include: 1) inflow to the major structures such as Shasta and Oroville Dams, 2) routing of flow downstream where both forecasts of flow and stage height are made for significant points, 3) forecasts of flow into the Sutter and Yolo Bypass systems, and 4) stage forecasts on tributary streams.

Flood problem areas in the Sacramento Basin Subregion are quite varied. Though the bypass systems are designed to divert large quantities of water during high water periods, forecasts of overflow at the weirs are required so that livestock and equipment can be moved to higher ground.

Forecasts of local flow in the reaches below Shasta, Oroville, and Bullards Bar Dams are required for scheduling releases from these structures so that the flood hazard can be reduced. Other areas of concern are along the main stem of Sacramento River where marinas and other facilities located inside the levees are subject to high water inundation. The forecasting points are shown on Map 4.

Major existing flood control storage projects in the subregion are operated to provide a maximum of 2,008,000 acre-feet of flood control storage during the most critical flood situations. These projects are:

Study area	Reservoir	Stream	Flood control capacity (ac.-ft.)	Drainage area (sq. miles)
Sacramento River Basin above Shasta Dam	Shasta Lake	Sacramento River	1,300,000	6,421
Stony Creek Basin	Black Butte	Stony Creek	150,000	740
Feather River Basin	Oroville	Feather River	155,000 (1965) 750,000 (1968)	3,611
American River Basin	Folsom	American River	400,000	1,861
Putah Creek Basin	Lake Berryessa (Monticello Dam)	Putah Creek	1/	566

1/ No specific flood control space, but flood control is a designated function utilizing surcharge storage (300,000 ac.-ft.) because outlet works have limited capacity.

These projects are shown on Map 3 and the three largest reservoirs in the subregion are shown in Photos SB-IV, SB-V, and SB-VI.

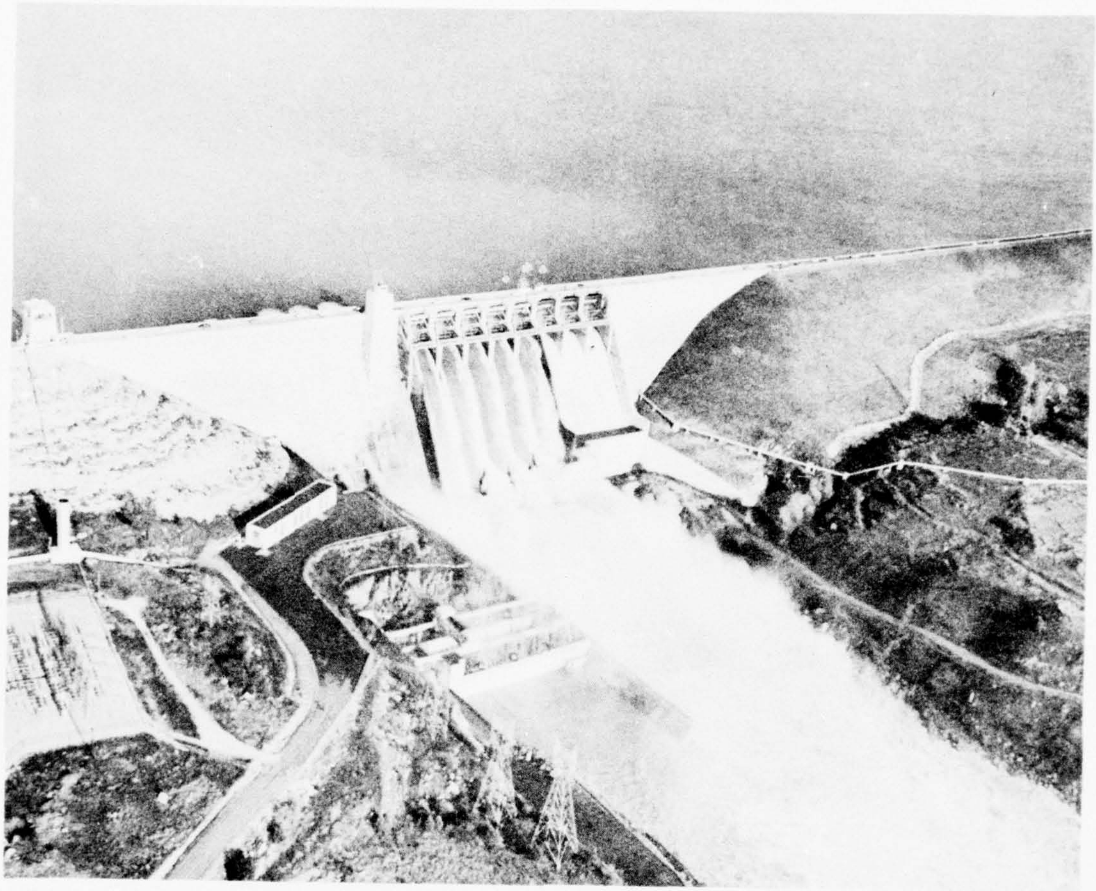
Other reservoirs in the subregion, though not having flood control as a designated function, provide incidental, but often significant, flood control benefits. Major reservoirs of this type are:

Reservoir	Stream	Constructing agency
Whiskeytown	Clear & Spring Creeks	Bureau of Reclamation
Bowman	Canyon Creek	Nevada Irrigation Dist.
Camp Far West	Bear River	South Sutter Water Dist.
Clear Lake Improvement	Cache Creek	Clear Lake Water Co.
Jackson Meadows	Middle Yuba River	Nevada Irrigation Dist.
L. L. Anderson	Middle Fork American R.	Placer Co. Water Agency
Lake Almanor	N. Fork Feather River	Pacific Gas & Electric Co.
Lake Spaulding	S. Fork Yuba River	Pacific Gas & Electric Co.
Little Grass Valley	S. Fork Feather River	Oroville Wyandotte Irrigation Dist.
Loon Lake	Gerle Creek	Sacramento Municipal Utility Dist.
Lower Hell Hole 1/	Rubicon River	Placer Co. Water Agency
Rollins	Bear River	Nevada Irrigation Dist.
Sly Creek	Lost Creek	Oroville Wyandotte Irrigation Dist.
Union Valley	Silver Creek	Sacramento Municipal Utility Dist.
Virginia Ranch	Dry Creek	Browns Valley Irrigation Dist.

1/ Partly completed 1965.

An extensively developed system of 851 miles of flood control levees, channels, and bypasses is another element in the overall flood control program of the subregion. Most of this integrated, continuous, system is part of the Sacramento River Flood Control Project 1/, a Federal-non-Federal-private interest undertaking. These features are indicated on Map 3 and data concerning the existing (1965) levee and channel projects are contained in Table 7.

1/ As supplemented and extended by the Sacramento River and Major and Minor Tributaries Project and the Sacramento River Bank Protection Project.



Folsom Dam on American River during the December 1964 flood. (Department of Water Resources Photo.)

PHOTO SB-IV

Shasta Dam on Sacramento River. (Bureau of Reclamation Photo.)

PHOTO SB-V

Oroville Dam and Reservoir on Feather River. (Department of Water Resources Photo.)

PHOTO SB-VI

Watershed treatment areas in the subregion supplement the other measures discussed previously. The Adobe Creek Watershed Project near Clear Lake is an excellent example. The installation of upstream floodwater retarding structures and channel improvement structural works are complemented by non-structural land treatment measures installed throughout the watershed by individuals. Some of these practices are range seeding, fire prevention and suppression, and diversion ditches.

The Flood Plain Management Services Program is covered in detail in the Regional Summary of this appendix. Flood plain information reports on streams in northeastern Sacramento County; the Morrison Creek Stream Group; Snodgrass Slough 2/; and the American, Feather, and Yuba Rivers have been completed. Under the program, flood hazard information is being furnished to private interests and local governmental agencies for evaluating the flood hazards associated with individual site locations.

In the Sacramento Basin Subregion, the accomplishments of the existing flood control improvements (and other measures that provide incidental flood control benefits) have been substantial. They have functioned effectively to reduce floodflows and flood damage. The flood control system existing in 1965 would have prevented $75 million in flood damages during the 1950 flood; $160 million in flood damages during the 1955 flood; and prevented $274 million in damages during the 1964-1965 flood. It is estimated that, on the average, existing measures prevent flood damages in excess of $25 million annually. Additional details are included in Table 2.

Although the existing flood control measures have functioned effectively, flood problems still exist in some areas. (See tabulation, Page SB-8.) The problems are especially serious on streams of the Redding Stream Group; in Colusa and Butte Basins; and along the Sacramento, Feather, Yuba, Bear, and American Rivers.

Damages from erosion in this subregion are substantial, with 7,850 miles of channel subject to some streambank erosion, of which 740 miles are considered "serious". Such damages, resulting primarily from high velocity flows, average in excess of $150,000 annually. Average land loss from channel banks sloughing amounts to about 250 acres annually, mostly in rural areas. The Sacramento River Bank Protection Project is directed towards restoring eroded banks and levees and prevention of further erosion. Sheet erosion is a problem on delta fans approaching the valley floor. This type of erosion is generated by high flow rates on unconfined streambeds and is particularly destructive to uncropped agricultural lands. (See Tables 1, 3 and 4 for flood damage categories, some of which index the magnitude of the erosion problem).

2/ The study areas for the Morrison Creek Stream Group and Snodgrass Slough reports overlap into the Delta-Central Subregion.

The aforementioned flood problems result in the following average annual damages.

Study area	Estimated average annual damages ($1,000) 1/
Sacramento River Basin above Shasta Dam	1,593 2/
Sacramento River-Shasta Dam to Sacramento	716
Redding Stream Group	626
Middle Sacramento River Tributaries-Eastside	271
Middle Sacramento River Tributaries-Westside	389
Stony Creek Basin	303
Butte Basin	841
Colusa Basin & Tributary Streams	674
Feather River Basin	3,117
Yuba River Basin	706
Bear River Basin	1,529
Coon Creek Stream Group	233
American River Basin	1,794
Cache Creek Basin	550
Putah Creek Basin	134
Morrison Creek Stream Group	125
Project Bypass in Sacramento Basin	4
Total Sacramento Basin Subregion	13,605

1/ Based on 1965 prices, economic conditions, and project conditions.
2/ Includes $451,000 in the State of Oregon.

Additional details are contained in Tables 3 and 4 for the subregion as a whole and in Table 9 for urban areas. Major urban damage centers and areas of the subregion subject to flooding are shown on Map 4.

Future Needs

It is evident from an examination of the current (1965) flood problems that additional flood control measures are required. It is estimated that average annual flood damages in the subregion (based on 1965 prices and conditions) amount to $13.6 million. The flood problems of the area will increase in the future due to the pressures of population and economic growth and resultant increases in use of flood plains. The population of the Sacramento Basin Subregion is projected to increase from 1,089,000 in 1965 to 1,534,000 in 1980, 2,742,000 in 2000 and 4,977,000 in 2020 (base plan projections). Average annual flood damages are estimated to increase as follows if additional flood control measures are not provided:

Projected Average Annual Flood Damages ($Million)

State	by 1980	by 2000	by 2020
California	20.2	37.0	82.0
Oregon	0.7	1.2	2.3
Subregion Total	20.9	38.2	84.3

Estimated damage data for existing and future conditions are contained in Table 5 and 9a.

Measures Required to Satisfy Future Needs

Improved flood forecasting will be a necessary part of a comprehensive flood control program. The optimum operation of flood control projects can only be approached by a well-coordinated system of forecasting. Updated forecast procedures as well as additional development of procedures to accommodate new projects will be required. New hydrologic data networks and telemetry will be necessary to improve the quality of the forecasts and to aid in the coordinated operation of projects. Costs of the required improvements to the flood forecasting system are estimated as follows:

Cost of Flood Forecasting Measures ($1,000)

State	1966-1980	1981-2000	2001-2020
California	1,389	1,129	1,089
Oregon	1	1	1
Subregion Total	1,390	1,130	1,090

Floodwater storage in reservoirs and detention structures will be an important element of the future flood control program. An additional 2,961,000 acre-feet of flood control capacity as shown in the following tabulation is required in the subregion to satisfy future needs.

Study area/ time frame in which needed	Reservoir	Stream	Flood control capacity (ac.-ft.)	Drainage area (sq. miles)
Sacramento River Basin above Shasta Dam 1/				
1966-1980	Detention Structures (6)	(Various)	14,000 1/	182
1981-2000	Allen Camp	Pit River	60,000	1,550
1981-2000	Detention Structures (4)	(Various)	13,000	913
2001-2020	Detention Structures (3)	(Various)	7,000 2/	180

Study area/ time frame in which needed	Reservoir	Stream	Flood control capacity (ac.-ft.)	Drainage area (sq. miles)
Redding Stream Group				
1966-1980	Dutch Gulch	Cottonwood Creek	250,000	392
1966-1980	Tehama	Cottonwood Creek	250,000	382
1981-2000	Saeltzer	Clear Creek	90,000	235
1981-2000	Bella Vista, Millvillito	Cow & Bear Creeks	125,000	283
1981-2000	Wing	Inks, Battle & Paynes Creeks	80,000	461
1981-2000	Detention Structures (10)	(Various)	29,000	91
2001-2020	Oak, Clover	Cow & Bear Creeks	32,000	82
2001-2020	Detention Structures (2)	(Various)	5,000	13
Middle Sacramento River Tributaries-Eastside				
1981-2000	Belle-Mill	Antelope Creek	39,000	153
1981-2000	Crown	Mill-Deer Creek	20,000	62
1981-2000	Sycamore	Big Chico Creek	30,000	70
1981-2000	Detention Structures (7)	(Various)	38,000	310
Middle Sacramento River Tributaries-Westside				
1966-1980	Paskenta	Thomes Creek	80,000	194
1981-2000	Galatin	Elder Creek	25,000	93
1981-2000	Detention Structure	(No Name)	1,000	5
2001-2020	Schoenfield	Red Bank Creek	12,000	47
2001-2020	Detention Structures (2)	(Various)	11,000	37
Stony Creek Basin				
2001-2020	Detention Structures (6)	(Various)	8,000	72
Colusa Basin and Tributary Streams				
1981-2000	Detention Structures (21)	(Various)	39,000	246
2001-2020	Detention Structure	(No Name)	2,000	37

Study area/ time frame in which needed	Reservoir	Stream	Flood control capacity (ac.-ft.)	Drainage area (sq. miles)
Butte Basin and Tributary Streams				
1981-2000	Covered Bridge	Butte Creek	30,000	148
1981-2000	Detention Structures (4)	(Various)	17,000	55
Feather River Basin				
1966-1980	Oroville 3/ 5/	Feather River	595,000	3,611
1966-1980	Detention Structure	(No Name)	5,000	34
1981-2000	Detention Structures (6)	(Various)	21,000	120
2001-2020	Detention Structures (11)	(Various)	23,000	148
Yuba River Basin				
1966-1980	Marysville	Yuba River	260,000	1,324
1966-1980	New Bullards Bar 5/	Yuba River	170,000	487
Bear River Basin				
1981-2000	Garden Bar	Bear River	125,000	286
1981-2000	Detention Structures (3)	(Various)	7,000	89
2001-2020	Spenceville	Dry Creek	25,000	57
Coon Creek Stream Group				
1966-1980	Detention Structures (3)	(Various)	11,000	167
American River Basin				
1966-1980 4/	Auburn	American River	250,000	982
Cache Creek Basin				
1966-1980	Detention Structure	(No Name)	2,000	11
1966-1980	Lakeport	Scotts Creek	24,000	53
1981-2000	Indian Valley	Cache Creek	40,000	121
1981-2000	Wilson Valley (Blue Ridge)	Cache Creek	65,000	801
1981-2000	Detention Structures (8)	(Various)	6,000	30
2001-2020	Kelseyville	Cache Creek	5,000	36

Study area/ time frame in which needed	Reservoir	Stream	Flood control capacity (ac.-ft.)	Drainage area (sq. miles)
Putah Creek Basin				
1966-1980	Detention Structure	(No Name)	2,000	30
1981-2000	Detention Structures (6)	(Various)	9,000	36
Morrison Creek Stream Group				
1966-1980	Vineyard	Elder and Laguna Creeks	9,000	37
Total			2,961,000	

1/ Includes 7,000 ac-ft in State of Oregon.
2/ State of Oregon.
3/ Oroville Reservoir partially completed 1965 (155,000 ac-ft). Total flood control capacity 750,000 ac-ft.
4/ Under construction or funded for construction as of FY 1970.
5/ Completed.

The reservoirs listed above are shown on Map 3 and additional information on flood control storage is contained in Table 6.

Costs for additional flood control capacity are estimated as follows:

Costs of Additional Reservoirs ($Million)

State	1966-1980	1981-2000	2001-2020
California	187.7	203.4	21.7
Oregon	2.1	0.0	3.3
Subregion Total	189.8	203.4	25.0

In addition, preliminary studies indicate that levee and channel work is desirable in the following areas of the subregion:

Study area	Levees (Bank Miles)	Channels (Miles)
Sacramento River Basin above Shasta Dam		
1966-1980	1	3
1981-2000	0	44
2001-2020	25	25
Sacramento River-Shasta Dam to Sacramento		
1966-1980	0	3
2001-2020	48	0
Redding Stream Group		
1966-1980	2	17
1981-2000	0	1
Middle Sacramento River Tributaries-Eastside		
1966-1980	0	5
1981-2000	15	5
2001-2020	28	0
Middle Sacramento River Tributaries-Westside		
1981-2000	12	10
Colusa Basin and Tributary Streams		
1981-2000	29	15
2001-2020	0	4
Butte Basin and Tributary Streams		
1981-2000	1	33
2001-2020	48	0
Feather River Basin		
1966-1980	11	7
2001-2020	15	9
Bear River Basin		
2001-2020	3	4
Coon Creek Stream Group		
2001-2020	15	5

Study area	Levees (Bank Miles)	Channels (Miles)
Cache Creek Basin		
1966-1980	0	36
1981-2000	0	4
Putah Creek Basin		
1966-1980	0	10
Morrison Creek Stream Group		
1966-1980	60	92
Total	313	332

The approximate location of levees and channel work is indicated on Map 3 and additional details are included in Table 7. The estimated costs for required levee and channel work are $40.5 million for the 1966-1980 period, $11.5 million for the 1981-2000 period, and $27.9 million for the 2001-2020 period.

The structural measures which have been included in the preceding paragraphs will be complemented by non-structural land treatment measures. Within this subregion conditions span the full spectrum of soils, climate and geology. Consequently, most of the land treatment practices listed in the Regional Summary of this appendix will be applicable. Map 3 shows potential watershed land treatment areas. Estimated costs and acres of land treatment measures are summarized below.

Land Treatment	1966-1980	1981-2000	2001-2020
Thousand acres	278	645	226
California	(278)	(530)	(226)
Oregon	(0)	(115)	(0)
Thousand dollars	2,150	4,170	2,590
California	(2,150)	(3,370)	(2,590)
Oregon	(0)	(800)	(0)

Flood plain zoning, flood proofing and other non-structural flood plain management measures will become a greater part of community planning in the SB Subregion because of existing and anticipated flood problems. Communities in this subregion with populations in excess of 2,500 with known significant flood problems include Alturas, Anderson, Dunsmuir, Redding, Davis, Dixon, Willows, Red Bluff, Saramento, Roseville, Folsom, Lincoln, Gridley, Quincy,

and Grass Valley. Many communities with expanding populations are expected to have flood problems in the future, and will be studied as their needs are made known. Flood plain information reports for Anderson, Redding, Red Bluff, Roseville, Lincoln and Quincy are scheduled for completion by 1980. It is anticipated that flood plain information reports for the remaining communities named above will be completed before the year 2000. Comprehensive flood damage prevention planning and implementation of flood plain management measures would follow in each flood problem area identified.

Damage reduction attributable to non-structural flood plain measures is shown in Table 9b. The Redding Stream Group and the American River Basin are the principal areas where such measures are considered to be applicable. Approximately 155 stream miles would be suitable for the non-structural flood plain management measures. Estimated costs for future flood plain management measures are as follows:

Cost of Flood Plain Management Measures ($Million)

State	1966-1980	1981-2000	2001-2020
California	4.5	6.6	22.9
Oregon	0.0	0.0	0.0
Subregion Total	4.5	6.6	22.9

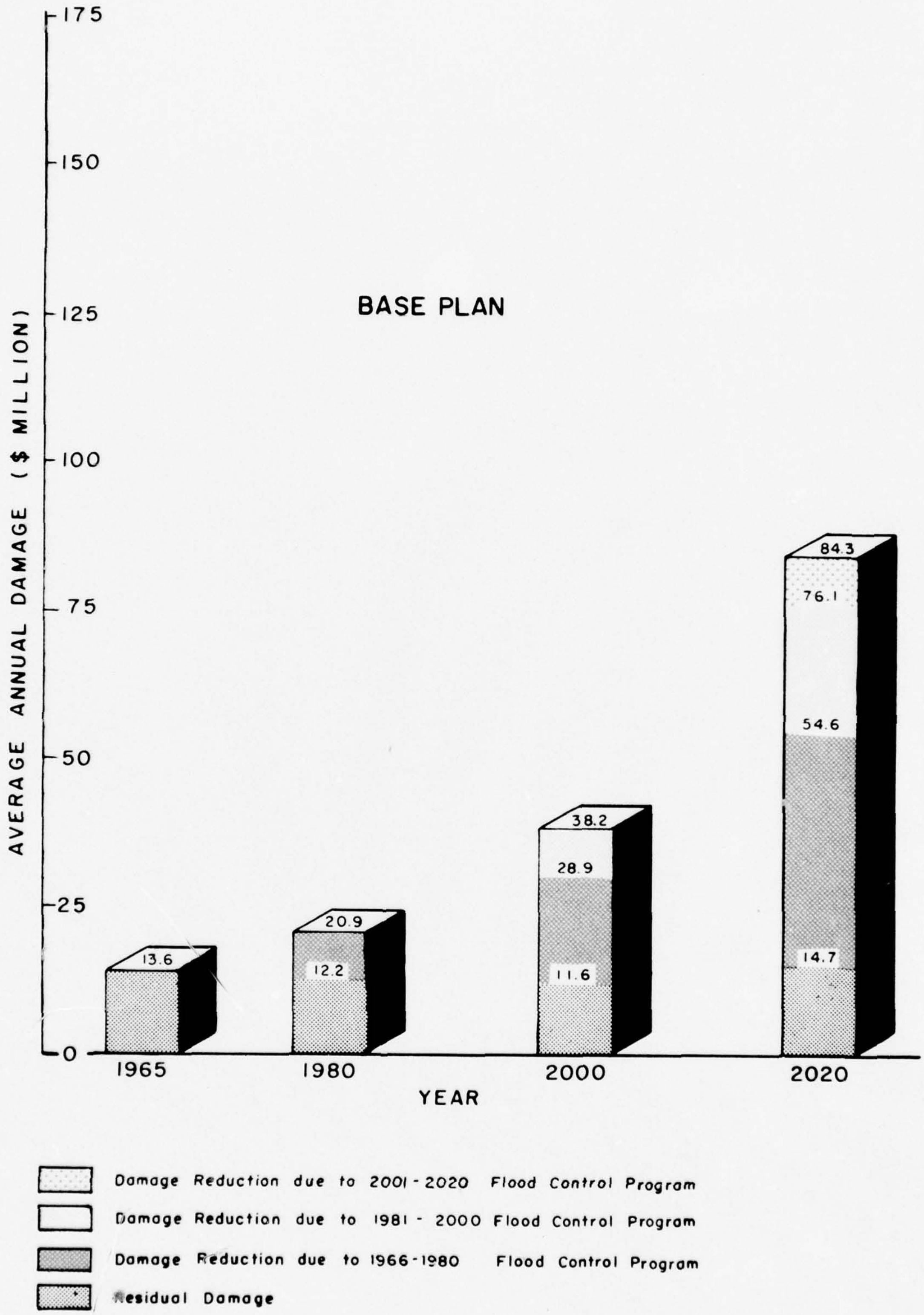
Potential to Satisfy Future Needs

The flood control program presented herein, would reduce projected average annual flood damages as follows:

Flood Damage Reduction ($Million)

State	by 1980	by 2000	by 2020
California	8.3	25.9	68.1
Oregon	0.4	0.7	1.5
Subregion Total	8.7	26.6	69.6

The total installation cost is estimated at about $238.3 million for the period 1966-1980, $226.8 million for 1981-2000, and $79.4 million for 2001-2020. Estimated annual OM&R costs for the 1966-1980, 1981-2000 and 2001-2020 portions of the flood control program are $1.83 million, $2.78 million and $2.65 million. (See Tables 10, 10a and 10b). The effect of the potential flood control program on future damages is in Table 8 and shown graphically on Figure SB-1, and its effect on flood flows is shown in Table 11.



CALIFORNIA REGION
COMPREHENSIVE FRAMEWORK STUDY

PROJECTED AVERAGE ANNUAL FLOOD DAMAGES

(1965 PRICES AND PROJECT CONDITIONS-DATA FROM TABLES 5 & 8)

APPENDIX IX

FIGURE SB-1

TABLE 1

SACRAMENTO BASIN SUBREGION OF THE CALIFORNIA REGION

Historical Flood Data

Study area	Flood	Location/ flow (cfs)	Area inundated (1,000 acres)	Flood damages 1/ - ($1,000) Forest & range resources	Forest & range facilities	Crop & pasture	Other agricultural	Land	Residential & commercial	Industrial & utility	Public facilities	Total
1	2	3	4	5	6	7	8	9	10	11	12	13
Sacramento River Basin above Shasta Dam	Dec55	Shasta Inflow 193,000 (Outflow 46,800)	20	7	1,269	13	66	62	31	88	165	1,701
	Dec64	Shasta Inflow 187,000 (Outflow 54,500)	54	30	1,372	43	227	212	232	2,000	1,201	5,317
Sacramento River-Shasta Dam to Sacramento	Feb40	Ord Ferry 370,000	44	0	0	223	207	191	270	16	683	1,590
	Dec55	Ord Ferry 170,000	41	0	0	199	193	176	14	48	576	1,206
	Feb58	Ord Ferry 240,000	32	0	0	516	502	457	102	46	888	2,511
	Dec64	Ord Ferry 186,000	44	0	0	556	449	351	538	37	1,485	3,416
Redding Stream Group	Dec55	Cottonwood Cr. nr. Cottonwood 49,000	6.0	1	50	19	81	76	5	17	117	366
	Dec64	Cottonwood Cr. nr. Cottonwood 60,500	5.9	1	53	44	185	167	82	32	1,068	1,632
Middle Sacramento River Tributaries-Eastside	Jan65	Big Chico Creek nr. Chico 9,500	1.8	0	20	60	12	17	42	22	754	927
Middle Sacramento River Tributaries-Westside	Dec64	Thomes Creek at Paskenta 37,800	9.8	0	341	211	260	388	56	455	1,098	2,809
Stony Creek Basin	Feb40	Unknown	20.9	0	48	8	63	63	9	0	9	200
	Feb58	Black Butte site 36,300	18.0	0	298	15	109	110	11	21	173	737
	Dec64	Black Butte Inflow 47,000 (Outflow 19,300)	3.1	0	472	6	44	44	0	6	542	1,114
Colusa Basin and Tributary Streams	Feb58	Willow Creek 14,000	80.0	0	0	754	201	50	0	0	212	1,217
Butte Basin and Tributary Streams	Mar07	Butte Creek nr. Chico 27,000				No damage data available						
	Feb58	Butte Creek nr. Chico 9,100	111.0	0	0	544	449	368	0	7	130	1,498
	Dec64	Butte Creek nr. Chico 21,200	100.4	0	0	331	273	223	6	61	167	1,061
Feather River Basin	Dec55	At Oroville 203,000	100.2	32	2,199	20,903	42	21	13,903	3,850	12,846	53,796
	Dec64	Oroville Inflow 250,000 (Outflow 158,000)	27.1	15	2,227	2,537	50	26	181	399	2,641	8,076
Yuba River Basin	Nov-Dec 50	Englebright Inflow 107,000 (Outflow 107,000)	43.4	0	579	213	167	127	1,989	105	1,434	4,614
	Dec55	Englebright Inflow 159,000 (Outflow 153,000)	4.4	0	978	162	127	97	153	392	2,189	4,098
	Jan-Feb 63	Englebright Inflow 150,000 (Outflow 150,000)	4.4	0	978	74	58	44	340	93	1,844	3,431

TABLE 1

SACRAMENTO BASIN SUBREGION OF THE CALIFORNIA REGION (CONT'D)

Historical Flood Data

Study area	Flood	Location/ flow (cfs)	Area inundated (1,000 acres)	Flood damages 1/ - ($1,000): Forest & range resources	Forest & range facilities	Crop & pasture	Other agricultural	Land	Residential & commercial	Industrial & utility	Public facilities	Total
1	2	3	4	5	6	7	8	9	10	11	12	13
Yuba River Basin (Cont'd)	Dec64	Englebright Inflow 176,000 (Outflow 171,000)	4.7	0	1,132	106	84	64	82	104	2,065	3,637
Bear River Basin	Dec55	Near Wheatland 33,000	12.5	0	0	239	350	542	47	335	464	1,977
Coon Creek Stream Group	Oct62	At Hwy 99E 7,500	17.2	0	0	198	22	19	2	4	35	280
	Jan67	Unknown	7.7	0	0	37	0	0	0	0	10	47
American River Basin	Nov50	At Folsom 210,000	9.1	0	1,796	350	150	12	1,621	188	1,184	5,301
	Dec64	Folsom Inflow 280,000 (Outflow 115,000)	3.8	9	2,395	13	0	0	247	420	1,837	4,921
Cache Creek Basin	Feb40	Near Capay 52,000				No damage breakdown available						
	Feb58	Near Capay 51,600	27.2	0	226	450	30	47	834	11	457	2,055
	Dec64	Near Capay 32,900	16.2	0	99	450	30	40	2	122	803	1,546
Putah Creek Basin	Feb40	Monticello Damsite 81,000				No damage breakdown available						
	Feb63	Monticello Dam 86,000	0.4	0	0	4	5	2	1	0	64	76
Morrison Creek Stream Group	Dec55	Morrison Creek nr. Sacramento 1,300	8.3	0	0	110	4	8	2	0	89	213
	Feb58	Morrison Creek nr. Sacramento 1,200	10.6	0	0	150	10	19	10	0	15	204
	Oct62	Morrison Creek nr. Sacramento 1,300	8.0	0	0	135	5	11	0	0	10	161
Project Bypass in Sacramento Basin	Mar07	Yolo at Lisbon 428,000				No damage data available						
	Dec55	Yolo at Lisbon 310,000	83.7	0	0	308	0	0	0	0	787	1,095
	Dec64	Yolo at Lisbon 370,000	92.4	0	0	1,253	0	0	0	17	2,129	3,399

1/ Data based on prices and project and economic conditions at time of occurrence of flood.

TABLE 2

SACRAMENTO BASIN SUBREGION OF THE CALIFORNIA REGION

Flood Damage 1/

Study area	Flood	Location/ flow (cfs)	Total damages - ($1,000): At time of flood 2/: Actual damage	At time of flood 2/: Damage without flood control projects	At time of flood 2/: Damage prevented by flood control projects 4/	1965 economic conditions & prices 3/: Damage with 1965 project conditions	1965 economic conditions & prices 3/: Damage without flood control projects	1965 economic conditions & prices 3/: Damage prevented by 1965 projects 5/
1	2	3	4	5	6	7	8	9
Sacramento River Basin above Shasta Dam	Dec64	Shasta Inflow 187,000 (Outflow 54,500)	5,317	5,317	0	5,317	5,317	0
Sacramento River-Shasta Dam to Sacramento	Dec64	Ord Ferry 186,000	3,416	81,491	78,075	3,416	81,491	78,075 6/
Redding Stream Group	Dec64	Cottonwood Creek nr. Cottonwood 60,000	1,632	1,632	0	1,632	1,632	0
Middle Sacramento River Tributaries-Eastside	Jan65	Big Chico Creek nr. Chico 9,500	927	2,588	1,661	927	2,588	1,661
Middle Sacramento River Tributaries-Westside	Dec64	Thomes Creek nr. Paskenta 37,800	2,809	4,270	1,461	2,809	4,270	1,461
Stony Creek Basin	Dec64	Black Butte Inflow 47,000 (Outflow 19,300)	1,114	1,673	559	1,114	1,673	559
Colusa Basin and Tributary Streams	Feb58	Willow Creek 14,000	1,217	1,217	0	1,294	1,294	0
Butte Basin and Tributary Streams	Dec64	Butte Creek nr. Chico 21,200	1,061	5,916	4,855	1,061	5,916	4,855
Feather River Basin	Dec64	Oroville Inflow 250,000 (Outflow 158,000)	8,076	71,474	63,398	8,076	71,474	63,398
Yuba River Basin	Dec64	Englebright Inflow 176,000 (Outflow 171,000)	3,637	3,637	0	3,637	3,637	0
Bear River Basin	Dec55	Near Wheatland 33,000	1,977	4,756	2,779	2,788	6,706	3,918
Coon Creek Stream Group	Oct62	At Hwy 99E 7,500	280	280	0	324	324	0
American River Basin	Dec64	At Folsom 280,000 (Outflow 115,000)	4,921	51,849	46,928	4,921	51,849	46,928
Cache Creek Basin	Feb58	Near Capay 51,600	2,055	2,401	346	2,192	2,604	412
Putah Creek Basin	Feb63	Monticello Inflow 86,000 (Outflow 10)	76	1,125	1,049	82	1,216	1,134
Morrison Creek Stream Group	Oct62	Morrison Creek nr. Sacramento 1,300	161	161	0	180	180	0
Project Bypass in Sacramento Basin	Dec64	Yolo at Lisbon 370,000	3,399	3,399	0	3,399	3,399	0

1/ Maximum flood for which data are available.
2/ Data based on prices and project and economic conditions at time of occurrence of flood.
3/ Data based on recurrence of original flood.
4/ Column 6 = column 5 - column 4.
5/ Column 9 = column 8 - column 7.
6/ Includes $40,000,000 flood damages prevented by Shasta Dam.

TABLE 3

SACRAMENTO BASIN SUBREGION OF THE CALIFORNIA REGION

Estimated Flood Damage for
the 100-Year Frequency Flood 1/
for Selected Streams

Study area/ stream	Area inundated (1,000 acres)	Flood damage 2/ - ($1,000) Forest & range resources	Forest & range facilities	Crop & pasture	Other agricultural	Land	Residential & commercial	Industrial & utilities	Public facilities	Total
1	2	3	4	5	6	7	8	9	10	11
Sacramento River Basin above Shasta Dam										
Sacramento River	113.9	9	1,715	1,336	1,312	549	966	661	651	7,199
Sacramento River-Shasta Dam to Sacramento										
Sacramento River	23.6	0	0	1,217	699	524	442	114	1,801	4,797
Redding Stream Group										
Cottonwood Creek	15.4	3	160	68	501	274	622	56	1,864	3,548
Middle Sacramento River Tributaries-Eastside										
Antelope Creek	13.3	0	46	1,180	239	82	51	179	826	2,603
Middle Sacramento River Tributaries-Westside										
Thomes Creek	14.3	4	348	432	382	525	259	646	1,307	3,903
Stony Creek Basin										
Stony Creek	0.8	0	1,026	1	64	116	50	5	341	1,603
Colusa Basin and Tributary Streams										
Willow Creek	87.9	0	0	839	622	713	1,791	638	849	5,452
Butte Basin and Tributary Streams										
Butte Basin	128.9	0	0	1,027	849	638	217	27	362	3,120
Feather River Basin										
Feather River	157.8	40	2,784	17,809	3,001	2,149	14,882	5,225	16,925	62,815
Yuba River Basin										
Yuba River	24.0	0	1,287	285	380	677	4,181	1,425	2,616	10,851
Bear River Basin										
Bear River	86.0	0	0	2,340	3,600	5,760	540	1,260	4,500	18,000
Coon Creek Stream Group										
Coon Creek	25.0	0	0	1,066	0	0	75	0	25	1,166
American River Basin										
American River	4.4	0	2,994	44	107	15	469	746	3,640	8,015
Cache Creek Basin										
Cache Creek	34.4	0	365	693	123	32	3,111	35	818	5,177
Putah Creek Basin										
Putah Creek	3.5	0	0	531	38	48	194	20	143	974
Morrison Creek Stream Group										
Morrison Creek	18.0	0	0	65	16	41	286	49	358	815
Project Bypass in Sacramento Basin										
Sutter Bypass	100.0	0	0	1,253	0	0	0	17	2,330	3,600

1/ See Table 11 for magnitude of 100-year flood at selected stations.
2/ Based on July 1965 prices, economic conditions, and project conditions.

TABLE 4

SACRAMENTO BASIN SUBREGION OF THE CALIFORNIA REGION

Estimated Average Annual Flood Damage

Study area (principal stream)	Flood damage 1/ - ($1,000)								
	Forest & range resources	Forest & range facilities	Crop & pasture	Other agricultural	Land	Residential & commercial	Industrial & utilities	Public facilities	Study area totals
1	2	3	4	5	6	7	8	9	10
Sacramento River Basin above Shasta Dam (Sacramento River)	2	343	341	378	180	159	89	101	1,593
Sacramento River - Shasta Dam to Sacramento (Sacramento River)	0	0	140	63	46	56	38	373	716
Redding Stream Group (Cottonwood Creek)	1	32	11	98	62	90	9	323	626
Middle Sacramento River Tributaries - Eastside (Antelope Creek)	0	9	146	40	10	11	9	46	271
Middle Sacramento River Tributaries - Westside (Thomes Creek)	1	70	36	37	51	12	61	121	389
Stony Creek Basin (Stony Creek)	0	205	Neg.	11	18	1	2	66	303
Colusa Basin and Tributary Streams (Willow Creek)	0	0	190	138	206	61	24	55	674
Butte Basin and Tributary Streams (Butte Basin)	0	0	311	247	136	28	4	115	841
Feather River Basin (Feather River)	8	557	795	245	130	525	208	649	3,117
Yuba River Basin (Yuba River)	0	257	13	18	37	108	86	187	706
Bear River Basin (Bear River)	0	0	199	306	489	46	107	382	1,529
Coon Creek Stream Group (Coon Creek)	0	0	213	0	0	15	0	5	233
American River Basin (American River)	0	599	9	119	3	330	232	502	1,794
Cache Creek Basin (Cache Creek)	0	73	108	13	5	233	4	114	550
Putah Creek Basin (Putah Creek)	0	0	82	5	7	22	4	14	134
Morrison Creek Stream Group (Morrison Creek)	0	0	10	3	4	44	8	56	125
Project Bypass in Sacramento Basin (Sutter Bypass)	0	0	1	0	0	0	1	2	4
Total Sacramento Basin Subregion	12	2,145	2,605	1,721	1,384	1,741	886	3,111	13,605

1/ Damages based on July 1965 prices, economic conditions, and project conditions.

TABLE 5

SACRAMENTO BASIN SUBREGION OF THE CALIFORNIA REGION

Summary of Estimated Average Annual Flood Damage for Present and Future Conditions of Economic Development with Existing Flood Control Measures

Study area (principal stream)	Average annual flood damages 1/ - ($1,000) 1965 economic conditions 2/	1980 economic conditions	2000 economic conditions	2020 economic conditions
1	2	3	4	5
Sacramento River Basin above Shasta Dam (Sacramento River)	1,593	2,331	3,669	6,688
Sacramento River-Shasta Dam to Sacramento (Sacramento River)	716	1,127	2,444	6,328
Redding Stream Group (Cottonwood Creek)	626	1,003	2,129	5,214
Middle Sacramento River Tributaries-Eastside (Antelope Creek)	271	399	690	1,373
Middle Sacramento River Tributaries-Westside (Thomes Creek)	389	606	1,153	2,785
Stony Creek Basin (Stony Creek)	303	358	491	813
Colusa Basin and Tributary Streams (Willow Creek)	674	967	1,498	2,442
Butte Basin and Tributary Streams (Butte Basin)	841	1,352	2,042	3,575
Feather River Basin (Feather River)	3,117	4,725	8,675	20,175
Yuba River Basin (Yuba River)	706	1,002	1,791	4,202
Bear River Basin (Bear River)	1,529	2,285	3,998	8,175
Coon Creek Stream Group (Coon Creek)	233	408	531	852
American River Basin (American River)	1,794	2,782	5,359	12,343
Cache Creek Basin (Cache Creek)	550	1,117	2,756	7,288
Putah Creek Basin (Putah Creek)	134	228	449	984
Morrison Creek Stream Group (Morrison Creek)	125	218	469	1,051
Project Bypass in Sacramento Basin (Sutter Bypass)	4	6	14	30
Total Sacramento Basin Subregion	13,605	20,914	38,158	84,318

1/ Damages based on July 1965 prices and project conditions, and estimated economic conditions for the year shown.
2/ Figures in column 2 are from column 10 of Table 4.

TABLE 6

SACRAMENTO BASIN SUBREGION OF THE CALIFORNIA REGION

Summary of Flood Control Capacity for Existing and Future Reservoirs

Study area	Flood control capacity 1/ - (1,000 ac-ft)				
	Existing projects (1965)	Projects 1966-1980 2/	Projects 1981-2000 2/	Projects 2001-2020 2/	Total projects as of 2020
1	2	3	4	5	6
Sacramento River Basin above Shasta Dam	0	14	73	7	94
Sacramento River - Shasta Dam to Sacramento	1,300	0	0	0	1,300
Redding Stream Group	0	500	324	37	861
Middle Sacramento River Tributaries - Eastside	0	0	127	0	127
Middle Sacramento River Tributaries - Westside	0	80	26	23	129
Stony Creek Basin	150	0	0	8	158
Colusa Basin and Tributary Streams	0	0	39	2	41
Butte Basin and Tributary Streams	0	0	47	0	47
Feather River Basin	155	600	21	23	799
Yuba River Basin	0	430	0	0	430
Bear River Basin	0	0	132	25	157
Coon Creek Stream Group	0	11	0	0	11
American River Basin	400	250	0	0	650
Cache Creek Basin	3	26	111	5	145
Putah Creek Basin	0	2	9	0	11
Morrison Creek Stream Group	0	9	0	0	9
Total Sacramento Basin Subregion	2,008	1,922	909	130	4,969

1/ Maximum flood control capacity. Does not include surcharge storage.
2/ Includes only reservoirs controlling the 100-year flood, or better, at the damsite above urban areas and reservoirs controlling at least the 10-year flood at the damsite where only rural areas are to be protected.

TABLE 7

SACRAMENTO BASIN SUBREGION OF THE CALIFORNIA REGION

Summary of Levee and Channel Flood Protection Projects
- Existing and Future -

Study area	Levee and channel projects									
	Existing projects (1965)		Projects 1966-1980 1/		Projects 1981-2000 1/		Projects 2001-2020 1/		Total projects as of 2020	
	Levees (miles)	Channels (miles)	Levees (miles)	Channels (miles)	Levees (miles)	Channels (miles)	Levees (miles)	Channels (miles)	Levees (miles)	Channels (miles)
1	2	3	4	5	6	7	8	9	10	11
Sacramento River Basin above Shasta Dam	0	0	1	3	0	44	25	25	26	72
Sacramento River-Shasta Dam to Sacramento	233 2/	0	0	3	0	0	48	0	281	3
Redding Stream Group	0	0	2	17	0	1	0	0	2	18
Middle Sacramento River Tributaries-Eastside	31	0	0	5	15	5	28	0	74	10
Middle Sacramento River Tributaries-Westside	8	0	0	0	12	10	0	0	20	10
Colusa Basin and Tributary Streams	36	0	0	0	29	15	0	4	65	19
Butte Basin and Tributary Streams	86	0	0	0	1	33	48	0	135	33
Feather River Basin	100	0	11	7	0	0	15	9	126	16
Yuba River Basin	13	0	0	0	0	0	0	0	13	0
Bear River Basin	54	0	0	0	0	0	3	4	57	4
Coon Creek Stream Group	37	0	0	0	0	0	15	5	52	5
American River Basin	34	0	0	0	0	0	0	0	34	0
Cache Creek Basin	73	5	0	36	0	4	0	0	73	45
Putah Creek Basin	31	0	0	10	0	0	0	0	31	10
Morrison Creek Stream Group	0	0	60	92	0	0	0	0	60	92
Project Bypass in Sacramento Basin	110	0	0	0	0	0	0	0	110	0
Total Sacramento Basin Subregion	846	5	74	173	57	112	182	47	1,159	337

1/ Includes only projects giving 100-year flood protection, or better, to urban areas and at least 10-year flood protection to agricultural areas.
2/ Projects include associated channel work in Sacramento Basin.

TABLE 8

SACRAMENTO BASIN SUBREGION OF THE CALIFORNIA REGION

Estimated Average Annual Flood Damage and Damage Reduction
- Present and Future Economic Conditions -

Study area (principal stream)	Total damages - 1965 prices ($1,000)									
	1965 economic	1980 economic conditions			2000 economic conditions			2020 economic conditions		
	& project conditions 1/	W/1965 project conditions 2/	Reduction in damages due to 1966-1980 flood control program 3/	Residual damage W/ 1966-1980 program 4/	W/1966-1980 program	Reduction in damages due to 1981-2000 flood control program 3/	Residual damage W/ 1981-2000 program 5/	W/1981-2000 program	Reduction in damages due to 2001-2020 flood control program 3/	Residual damage W/ 2001-2020 program 6/
1	2	3	4	5	6	7	8	9	10	11
Sacramento River Basin above Shasta Dam (Sacramento River)	1,593	2,331	654	1,677	2,538	530	2,008	3,604	677	2,927
Sacramento River-Shasta Dam to Sacramento (Sacramento River)	716	1,127	294	833	1,885	385	1,500	4,084	3,109	975
Redding Stream Group (Cottonwood Creek)	626	1,003	378	625	1,406	785	621	1,444	332	1,112
Middle Sacramento River Tributaries-Eastside (Antelope Creek)	271	399	55	344	609	503	106	224	0	224
Middle Sacramento River Tributaries-Westside (Thomes Creek)	389	606	491	115	219	80	139	334	90	244
Stony Creek Basin (Stony Creek)	303	358	1	357	488	0	488	808	258	550
Colusa Basin and Tributary Streams (Willow Creek)	674	967	203	764	1,138	340	798	1,174	102	1,072
Butte Basin and Tributary Streams (Butte Basin)	841	1,352	270	1,082	1,634	615	1,019	2,265	997	1,268
Feather River Basin (Feather River)	3,117	4,725	3,743	982	1,511	205	1,306	2,567	1,219	1,348
Yuba River Basin (Yuba River)	706	1,002	530	472	573	0	573	792	0	792
Bear River Basin (Bear River)	1,529	2,285	2	2,283	3,992	3,591	401	881	224	657
Coon Creek Stream Group (Coon Creek)	233	408	290	118	184	136	48	77	0	77
American River Basin (American River)	1,794	2,782	1,105	1,677	2,437	198	2,239	3,680	1,048	2,632
Cache Creek Basin (Cache Creek)	550	1,117	290	827	2,043	1,845	198	523	65	458
Putah Creek Basin (Putah Creek)	134	228	172	56	138	47	91	300	126	174
Morrison Creek Stream Group (Morrison Creek)	125	218	190	28	60	0	60	134	0	134
Project Bypass in Sacramento Basin (Sutter Bypass)	4	6	0	6	14	0	14	30	0	30
Total Sacramento Basin Subregion	13,605	20,914	8,668	12,246	20,869	9,260	11,609	22,921	8,247	14,674

1/ Figures shown in column 2 are from column 10 of Table 4 and are also shown in column 2 of Table 5.
2/ Figures in column 3 are from column 3 of Table 5.
3/ Includes structural and non-structural measures.
4/ Column 5 = column 3 - column 4.
5/ Column 8 = column 6 - column 7.
6/ Column 11 = column 9 - column 10.

TABLE 9

SACRAMENTO BASIN SUBREGION OF THE CALIFORNIA REGION

Estimated Average Annual Flood Damage for Urban Areas with Significant Flood Problems

Study area/ stream	Damage center	Average annual flood damages ($1,000) 1/ Residential	Commercial	Industrial & utilities	Public facilities	Total
1	2	3	4	5	6	7
Sacramento River Basin above Shasta Dam						
Pit River	Alturas	33	13	1	3	50
Sacramento River	Dunsmuir	6	0	6	9	21
Redding Stream Group						
Sacramento River and Redding Area Streams	Anderson	0	0	1	15	16
"	Redding	20	50	3	22	95
Middle Sacramento River Tributaries-Eastside						
Big Chico Creek	Chico	1	1	0	2	4
Stony Creek Basin						
Stony Creek	Orland	0	0	1	1	2
Colusa Basin and Tributary Streams						
Willow Creek	Willows	41	11	18	22	92
Butte Basin and Tributary Streams						
Big Chico Creek	Chico	8	4	2	6	20
Feather River Basin						
Feather River	Gridley	1	1	0	3	5
Feather River	Quincy	1	1	1	8	11
Feather River	Oroville	62	37	21	86	206
Feather River	Marysville	19	7	9	16	51
Yuba River Basin						
Yuba River	Marysville	40	15	19	34	108
Bear River Basin						
Wolf Creek	Grass Valley	0	0	1	4	5
American River Basin						
American River	Folsom	0	1	3	2	6
American & Sacramento Rivers	Sacramento	248	74	209	379	910
Dry Creek	Roseville	1	2	4	7	14
Cache Creek Basin						
Cache Creek	Woodland	3	1	0	1	5
Putah Creek Basin						
Putah Creek	Davis	2	1	2	3	8
Dickson Creek	Dixon	1	1	1	2	5
Morrison Creek Stream Group						
Morrison Creek	Sacramento	38	6	8	20	72
Total Sacramento Basin Subregion		525	226	310	645	1,706

1/ Damages are based on July 1965 prices, economic conditions, and project conditions.

TABLE 9a

SACRAMENTO BASIN SUBREGION OF THE CALIFORNIA REGION

Summary of Estimated Average Annual Flood Damage for Urban Areas with Significant Flood Problems
- Present and Future Conditions of Economic Development
with Existing Flood Control Measures -

Study area/ stream	Damage center	Average annual flood damages 1/ - ($1,000) 1965 economic conditions 2/	1980 economic conditions	2000 economic conditions	2020 economic conditions
1	2	3	4	5	6
Sacramento River above Shasta Dam					
Pit River	Alturas	50	109	240	573
Sacramento River	Dunsmuir	21	39	86	221
Redding Stream Group					
Sacramento River & Redding Area Streams	Anderson	16	26	61	156
"	Redding	95	183	429	1,097
Middle Sacramento River Tributaries-Eastside					
Big Chico Creek	Chico	4	7	17	51
Stony Creek Basin					
Stony Creek	Orland	2	3	7	16
Colusa Basin and Tributary Streams					
Willow & Walker Creeks	Willows	92	149	291	714
Butte Basin and Tributary Streams					
Little Chico Creek	Chico	20	37	88	257
Feather River Basin					
Feather River	Gridley	5	9	21	61
Feather River	Quincy	11	18	42	127
Feather River	Oroville	206	375	885	2,565
Feather & Yuba Rivers	Marysville	159	269	601	1,593
Bear River Basin					
Wolf Creek	Grass Valley	5	8	16	44
American River Basin					
American River	Folsom	6	11	24	58
American & Sacramento Rivers	Sacramento	910	1,668	3,648	9,324
Dry Creek	Roseville	14	25	55	132
Cache Creek Basin					
Cache Creek	Woodland	5	10	29	97
Putah Creek Basin					
Dickson Creek	Dixon	5	13	38	90
Putah Creek	Davis	8	15	40	130
Morrison Creek Stream Group					
Morrison Creek	Sacramento	72	136	304	726
Total Sacramento Basin Subregion		1,706	3,110	6,922	18,032

1/ Damages based on July 1965 prices and project conditions, and estimated economic conditions for the year shown.
2/ Figures in column 3 are from column 7, "Total," shown on Table 9.

TABLE 9b

SACRAMENTO BASIN SUBREGION OF THE CALIFORNIA REGION

Estimated Average Annual Flood Damage and Damage Reduction
for Urban Areas with Significant Flood Problems
- Present and Future Economic Conditions -

Study area/ stream	Damage center	Total damages - 1965 prices ($1,000): 1965	1980 economic conditions				2000 economic conditions				2020 economic conditions			
		economic & project conditions 1/	W/1965 project conditions 2/	Reduction due to 1966-1980 program: Non-structural measures	Reduction due to 1966-1980 program: Structural measures	Residual damage w/1966-1980 program 3/	W/1966-1980 program	Reduction due to 1981-2000 program: Non-structural measures	Reduction due to 1981-2000 program: Structural measures	Residual damage w/1981-2000 program 4/	W/1981-2000 program	Reduction due to 2001-2020 program: Non-structural measures	Reduction due to 2001-2020 program: Structural measures	Residual damage w/2001-2020 program 5/
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Sacramento River above Shasta Dam														
Pit River	Alturas	50	109	5	96	8	15	5	0	10	24	18	0	6
Sacramento River	Dunsmuir	21	39	14	0	25	72	38	0	34	169	129	0	40
Redding Stream Group														
Sacramento River & Redding Area Streams	Anderson	16	26	7	0	19	54	20	26	8	20	8	0	12
	Redding	95	183	95	55	33	77	13	26	38	97	39	0	58
Middle Sacramento River Tributaries-Eastside														
Big Chico Creek	Chico	4	7	0	0	7	17	0	0	17	51	0	0	51
Stony Creek Basin														
Stony Creek	Orland	2	3	0	0	3	7	0	0	7	16	0	0	16
Colusa Basin and Tributary Streams														
Willow & Walker Creeks	Willows	92	149	14	104	31	60	23	0	37	91	44	0	47
Butte Basin and Tributary Streams														
Little Chico Creek	Chico	20	37	0	0	37	88	0	0	88	257	0	0	257
Feather River Basin														
Feather River	Gridley	5	9	3	0	6	18	10	0	8	48	37	0	11
Feather River	Quincy	11	18	6	0	12	36	19	0	17	102	68	0	34
Feather River	Oroville	206	375	0	368	7	17	0	0	17	49	0	12	37
Feather & Yuba Rivers	Marysville	159	269	0	255	14	33	0	0	33	82	0	52	30
Bear River Basin														
Wolf Creek	Grass Valley	5	8	2	0	6	14	6	0	8	36	22	0	14
American River Basin														
American River	Folsom	6	11	4	0	7	20	10	0	10	44	27	0	17
American & Sacramento Rivers	Sacramento	910	1,668	65	777	826	1,313	164	0	1,149	2,045	530	256	1,259
Dry Creek	Roseville	14	25	9	0	16	46	24	0	22	99	62	0	37
Cache Creek Basin														
Cache Creek	Woodland	5	10	0	0	10	29	0	28	1	3	0	0	3
Putah Creek Basin														
Dickson Creek	Dixon	5	13	6	0	7	32	20	0	12	64	46	0	18
Putah Creek	Davis	8	15	6	0	9	34	20	0	14	104	80	0	24
Morrison Creek Stream Group														
Morrison Creek	Sacramento	72	136	0	122	14	31	0	0	31	74	0	0	74
Total Sacramento Basin Subregion		1,706	3,110	236	1,777	1,097	2,013	372	80	1,561	3,475	1,110	320	2,045

1/ Figures shown in column 3 are from column 7 of Table 9 and are also shown in column 3 of Table 9a.
2/ Figures in column 4 are from column 4 of Table 9a.
3/ Column 7 = column 4 - column 5 - column 6.
4/ Column 11 = column 8 - column 9 - column 10.
5/ Column 15 = column 12 - column 13 - column 14.

TABLE 10

SACRAMENTO BASIN SUBREGION OF THE CALIFORNIA REGION

Estimated Costs of Future Flood Control [illegible]am
- 1966 to 1980 -
($1,000)

Study area	Levees & channels				Flood control reservoirs				Non-structural measures			
	Federal		Non-Federal		Federal		Non-Federal		Federal		Non-Federal	
	Installation costs	Annual OM&R costs	Installation costs	Annual OM&R costs	Installation costs	Annual OM&R costs	Installation costs	Annual OM&R costs	Installation costs	Annual OM&R costs	Installation costs	Annual OM&R costs
1	2	3	4	5	6	7	8	9	10	11	12	13
Sacramento River above Shasta Dam	660	0	240	8	3,610	0	480	16	310	37	730	61
Sacramento River-Shasta Dam to Sacramento	0	0	0	0	0	0	0	0	200	160	200	200
Redding Stream Group	1,960	0	350	11	38,000	58	0	0	220	96	1,880	51
Middle Sacramento River Tributaries-Eastside	300	0	80	3	0	0	0	0	40	9	60	12
Middle Sacramento River Tributaries-Westside	0	0	0	0	14,010	7	0	0	40	7	40	7
Stony Creek Basin	0	0	0	0	0	0	0	0	80	16	60	10
Colusa Basin and Tributary Streams	0	0	0	0	0	0	0	0	40	6	380	13
Butte Basin and Tributary Streams	0	0	0	0	0	0	0	0	70	25	80	33
Feather River Basin	4,140	0	1,730	43	70,480	0	150	6	210	47	530	139
Yuba River Basin	0	0	0	0	34,870	88	0	0	110	47	160	57
Bear River Basin	0	0	0	0	0	0	0	0	20	8	70	10
Coon Creek Stream Group	0	0	0	0	1,850	0	1,010	7	20	4	30	5
American River Basin	0	0	0	0	8,220	5	0	0	160	41	1,800	83
Cache Creek Basin	2,690	0	430	31	4,240	39	800	23	50	14	70	23
Putah Creek Basin	650	0	350	5	570	0	500	9	20	7	240	14
Morrison Creek Stream Group	11,000	0	15,880	162	5,410	0	5,630	35	10	1	10	2
Project Bypass in Sacramento Basin	0	0	0	0	0	0	0	0	30	18	30	15
Total Sacramento Basin Subregion	21,400	0	19,060	263	181,260	197	8,570	96	1,630	543	6,370	735

TABLE 10a

SACRAMENTO BASIN SUBREGION OF THE CALIFORNIA REGION

Estimated Costs of Future Flood Control Program
- 1981 to 2000 -
($1,000)

Study area	Levees & channels				Flood control reservoirs				Non-structural measures			
	Federal		Non-Federal		Federal		Non-Federal		Federal		Non-Federal	
	Installation costs	Annual OM&R costs	Installation costs	Annual OM&R costs	Installation costs	Annual OM&R costs	Installation costs	Annual OM&R costs	Installation costs	Annual OM&R costs	Installation costs	Annual OM&R costs
1	2	3	4	5	6	7	8	9	10	11	12	13
Sacramento River above Shasta Dam	3,460	0	320	80	10,090	19	180	17	490	93	2,300	146
Sacramento River-Shasta Dam to Sacramento	0	0	0	0	0	0	0	0	200	240	200	280
Redding Stream Group	170	0	120	6	26,360	90	1,650	18	170	118	860	85
Middle Sacramento River Tributaries-Eastside	210	0	130	12	33,850	40	1,360	83	70	18	120	26
Middle Sacramento River Tributaries-Westside	1,340	0	700	12	2,020	13	320	3	50	13	90	17
Stony Creek Basin	0	0	0	0	0	0	0	0	90	27	140	23
Colusa Basin and Tributary Streams	2,490	0	1,220	23	7,690	0	1,360	37	110	15	560	32
Butte Basin and Tributary Streams	920	0	30	22	8,200	14	210	19	60	37	110	49
Feather River Basin	0	0	0	0	8,580	0	440	33	280	87	1,060	219
Yuba River Basin	0	0	0	0	0	0	0	0	130	74	190	89
Bear River Basin	0	0	0	0	9,490	33	80	4	40	14	170	19
Coon Creek Stream Group	0	0	0	0	0	0	0	0	30	8	60	13
American River Basin	0	0	0	0	0	0	0	0	160	65	2,970	124
Cache Creek Basin	260	0	120	4	83,770	37	230	15	100	35	150	49
Putah Creek Basin	0	0	0	0	5,680	0	1,790	22	60	13	710	28
Morrison Creek Stream Group	0	0	0	0	0	0	0	0	20	4	40	8
Project Bypass in Sacramento Basin	0	0	0	0	0	0	0	0	50	28	70	25
Total Sacramento Basin Subregion	8,850	0	2,640	159	195,730	246	7,620	251	2,110	889	9,800	1,232

TABLE 10b

SACRAMENTO BASIN SUBREGION OF THE CALIFORNIA REGION

Estimated Costs of Future Flood Control Program
- 2001 to 2020 -
($1,000)

Study area	Levees & channels				Flood control reservoirs				Non-structural measures			
	Federal		Non-Federal		Federal		Non-Federal		Federal		Non-Federal	
	Installation costs	Annual OM&R costs	Installation costs	Annual OM&R costs	Installation costs	Annual OM&R costs	Installation costs	Annual OM&R costs	Installation costs	Annual OM&R costs	Installation costs	Annual OM&R costs
1	2	3	4	5	6	7	8	9	10	11	12	13
Sacramento River above Shasta Dam	1,360	0	40	30	3,950	0	590	15	330	76	6,320	122
Sacramento River-Shasta Dam to Sacramento	3,170	0	1,630	30	0	0	0	0	200	320	200	360
Redding Stream Group	0	0	0	0	3,180	17	330	3	160	131	5,290	114
Middle Sacramento River Tributaries-Eastside	0	0	0	0	0	0	0	0	50	18	80	23
Middle Sacramento River Tributaries-Westside	0	0	0	0	4,240	7	680	14	30	12	60	14
Stony Creek Basin	0	0	0	0	870	0	490	3	60	27	90	16
Colusa Basin and Tributary Streams	80	0	10	1	470	0	30	3	70	9	600	20
Butte Basin and Tributary Streams	9,650	0	5,970	48	0	0	0	0	50	42	70	52
Feather River Basin	3,200	0	840	45	6,150	0	640	26	200	94	1,520	236
Yuba River Basin	0	0	0	0	0	0	0	0	90	87	140	101
Bear River Basin	840	0	640	4	2,550	13	0	0	30	17	340	20
Coon Creek Stream Group	330	0	180	3	0	0	0	0	20	9	40	11
American River Basin	0	0	0	0	0	0	0	0	160	80	8,250	159
Cache Creek Basin	0	0	0	0	800	1	0	0	60	44	90	50
Putah Creek Basin	0	0	0	0	0	0	0	0	50	12	1,760	32
Morrison Creek Stream Group	0	0	0	0	0	0	0	0	10	5	30	11
Project Bypass in Sacramento Basin	0	0	0	0	0	0	0	0	40	35	40	25
Total Sacramento Basin Subregion	18,630	0	9,310	161	22,210	38	2,760	64	1,610	1,018	24,920	1,366

June 1971

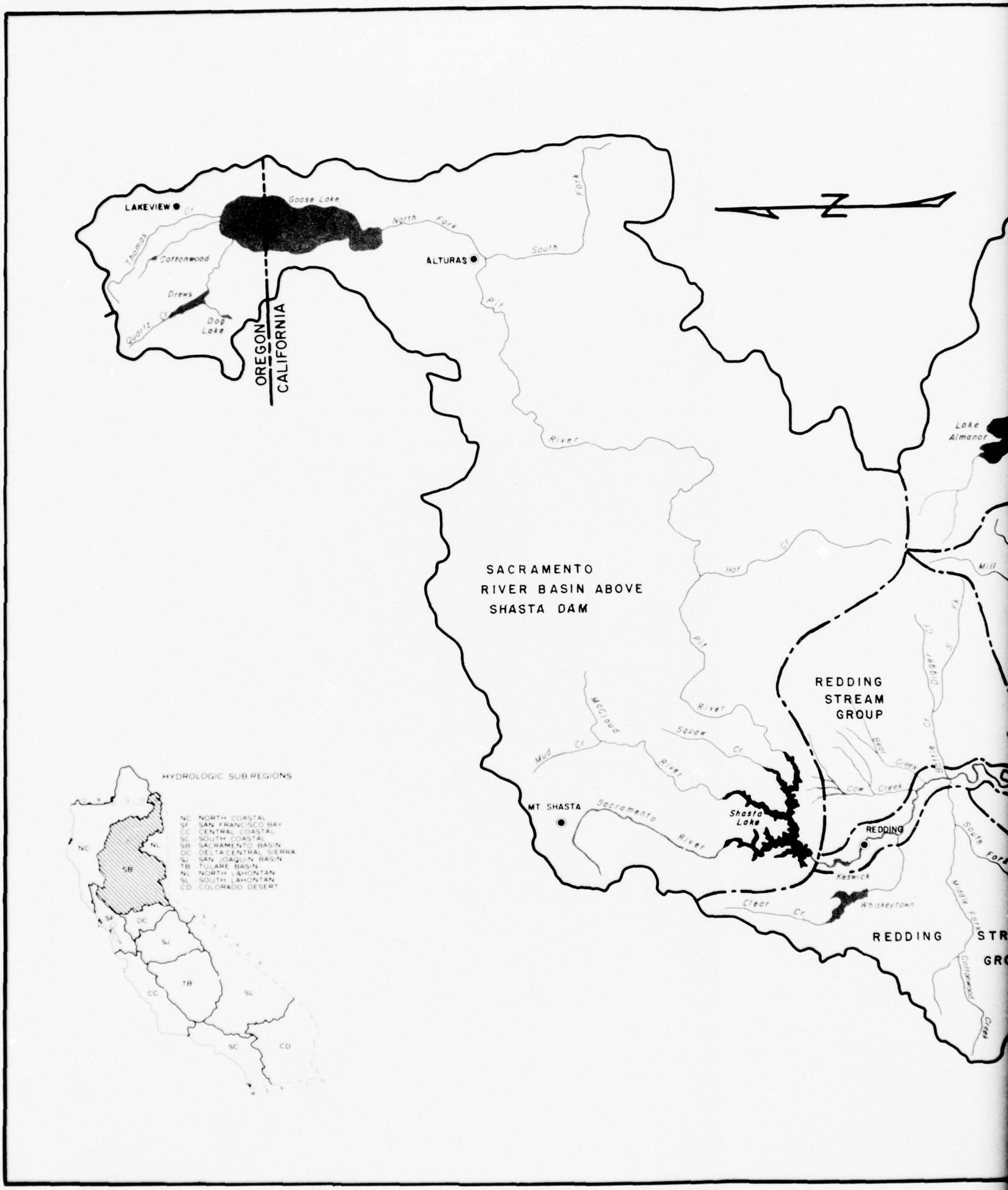
TABLE 11

SACRAMENTO BASIN SUBREGION OF THE CALIFORNIA REGION

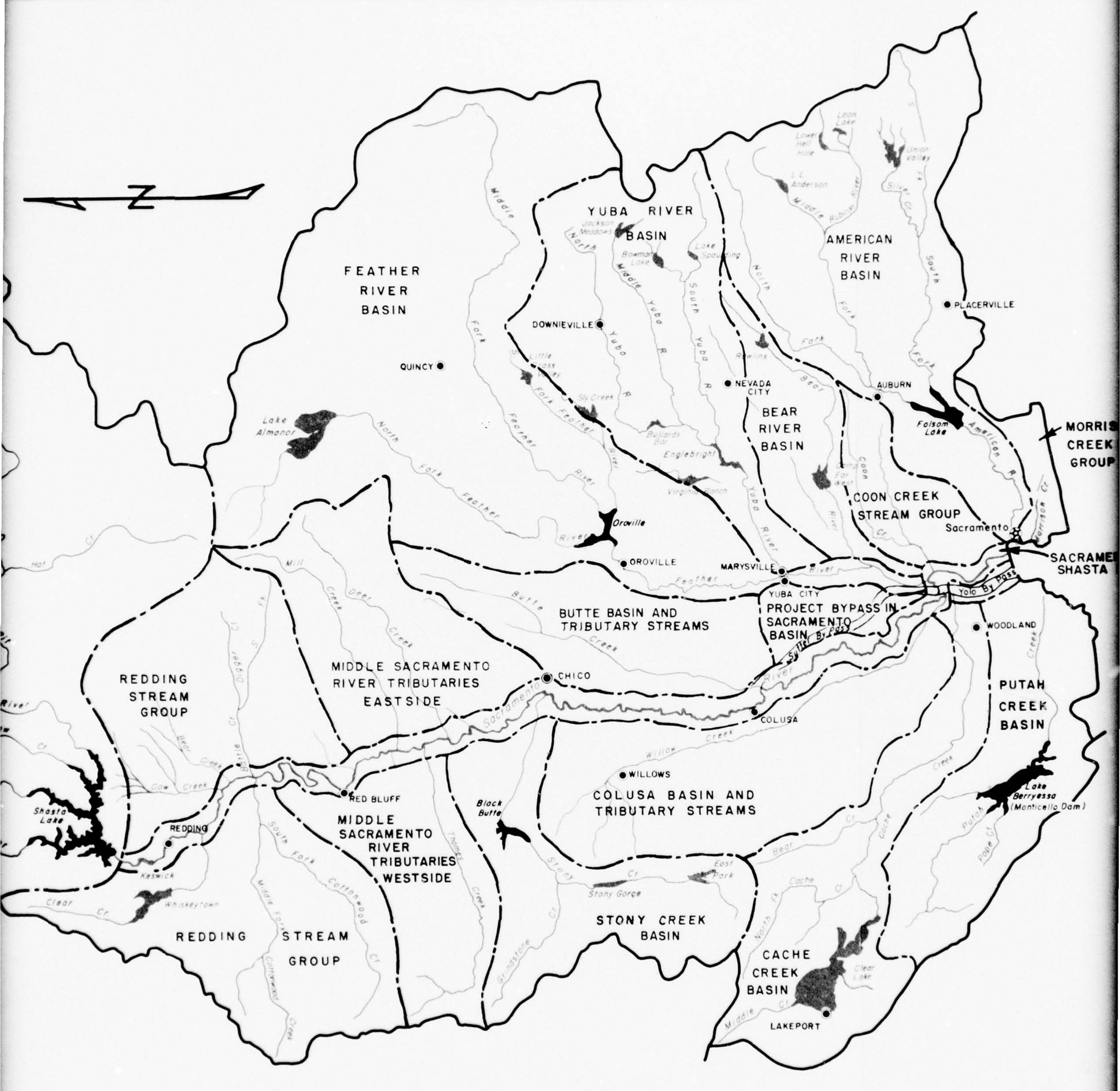
Flow Data at Selected Locations
(Flows in 1,000 cfs)

Study area/ stream	Location	Non-damaging flow 1/	Maximum flood of record: Date	Maximum flood of record, Flow: At time of occurrence	Maximum flood of record, Flow: Existing (1965) project conditions	Maximum flood of record, Flow: Future project conditions 2/ 1980	Future project conditions 2/ 2000	Future project conditions 2/ 2020	Flow of standard project flood: Existing (1965) project conditions	Flow of standard project flood: Future project conditions 2/ 1980	Future project conditions 2/ 2000	Future project conditions 2/ 2020	Flow of 100-year frequency flood: Existing (1965) project conditions	Flow of 100-year frequency flood: Future project conditions 2/ 1980	Future project conditions 2/ 2000	Future project conditions 2/ 2020
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Sacramento River Basin above Shasta Dam																
Sacramento River	Shasta															
	Inflow		22Dec55	193	193	193	193	193	343	343	343	343	252	252	252	252
	Outflow	80	22Dec55	47	47	47	47	47	150	150	150	150	80	80	80	80
Sacramento River-Shasta Dam to Sacramento																
Sacramento River	Ord Ferry	105	28Feb40	370	192	164	155	152	410	350	330	325	248	200	185	180
	Ord Ferry		25Feb58	240	240	215	203	200								
Redding Stream Group																
Cottonwood Creek	Near Cottonwood	15	22Dec64	60	60	6	6	6	130	29	29	29	110	15	15	15
Middle Sacramento River Tributaries-Eastside																
Big Chico Creek	Near Chico	10	5Jan65	10	10	10	9	9	16	16	14	14	13	10	10	10
Middle Sacramento River Tributaries-Westside																
Thomes Creek	At Paskenta	5	22Dec64	38	38	5	5	5	46	11	11	11	40	7	7	7
Stony Creek Basin																
Stony Creek	Black Butte															
	Inflow		23Dec64	47	47	47	47	47	95	95	95	95	78	78	78	78
	Outflow	10	23Dec64	19	19	19	19	19	21	21	21	21	15	15	15	15
Colusa Basin and Tributary Streams																
Willow Creek	Willow Creek	1	24Feb58	14	14	14	14	14	22	22	22	22	20	20	20	20
Butte Basin and Tributary Streams																
Butte Creek	Near Chico	15	19Mar07	27	27	27	16	16	43	43	36	36	30	30	20	20
Feather River Basin																
Feather River	Oroville															
	Inflow		22Dec64	250	250	250	250	250	440	440	440	440	320	320	320	320
	Outflow	150	22Dec64	158	158	150	150	150	3/	150	150	150	3/	150	150	150
Yuba River Basin																
Yuba River	At mouth	120	22Dec64	180	180	100	100	100	280	120	120	120	200	120	120	120
Bear River Basin																
Bear River	Near Wheatland	30	22Dec55	33	33	33	21	21	73	73	25	25	62	62	24	24
Coon Creek Stream Group																
Coon Creek	At Hwy 99E	4/	Oct62	8	8	8	8	8	18	18	18	18	14	12	12	12
American River Basin																
American River	Folsom															
	Inflow		23Dec64	280	210	130	130	130	460	290	290	290	330	170	170	170
	Outflow	115	23Dec64	115	115	115	115	115	380	115	115	115	115	115	115	115
Cache Creek Basin																
Cache Creek	Near Capay	21	Feb40	52	52	41	21	21	77	70	24	24	60	50	17	17
Putah Creek Basin																
Putah Creek	Monticello															
	Inflow		25Feb40	81	81	81	81	81	110	110	110	110	90	90	90	90
	Outflow	62	25Feb40	--	4/	4/	4/	4/	13	13	13	13	10	10	10	10
Morrison Creek Stream Group																
Morrison Creek	Near Sacramento	4	14Oct62	1	1	1	1	1	7	4	4	4	5	4	4	4

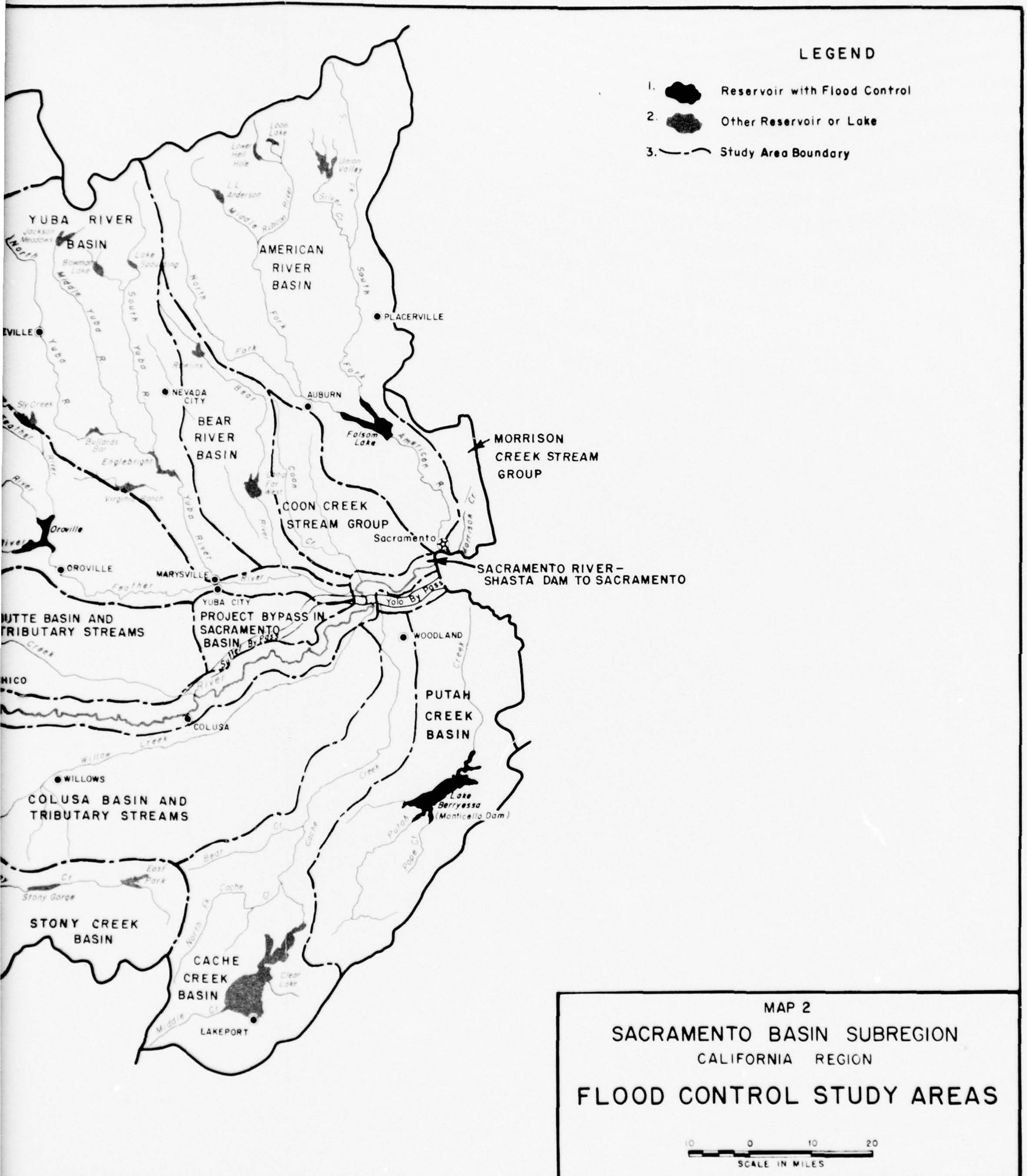
1/ Under 1965 project conditions.
2/ Flows as modified by future projects likely to be in a future flood control program by the years 1980, 2000, and 2020.
3/ Oroville Reservoir under construction (1965).
4/ Less than 1,000 cfs.



N
SACRAMENTO
RIVER BASIN ABOVE
SHASTA DAM
REDDING
STREAM
GROUP
REDDING
LAKEVIEW
ALTURAS
MT. SHASTA
OREGON
CALIFORNIA
Goose Lake
Cottonwood
Drews
Dog Lake
Lake Almanor
Shasta Lake
Keswick
Whiskeytown
HYDROLOGIC SUB-REGIONS
NC NORTH COASTAL
SF SAN FRANCISCO BAY
CC CENTRAL COASTAL
SC SOUTH COASTAL
SB SACRAMENTO BASIN
DC DELTA CENTRAL SIERRA
SJ SAN JOAQUIN BASIN
TB TULARE BASIN
NL NORTH LAHONTAN
SL SOUTH LAHONTAN
CD COLORADO DESERT

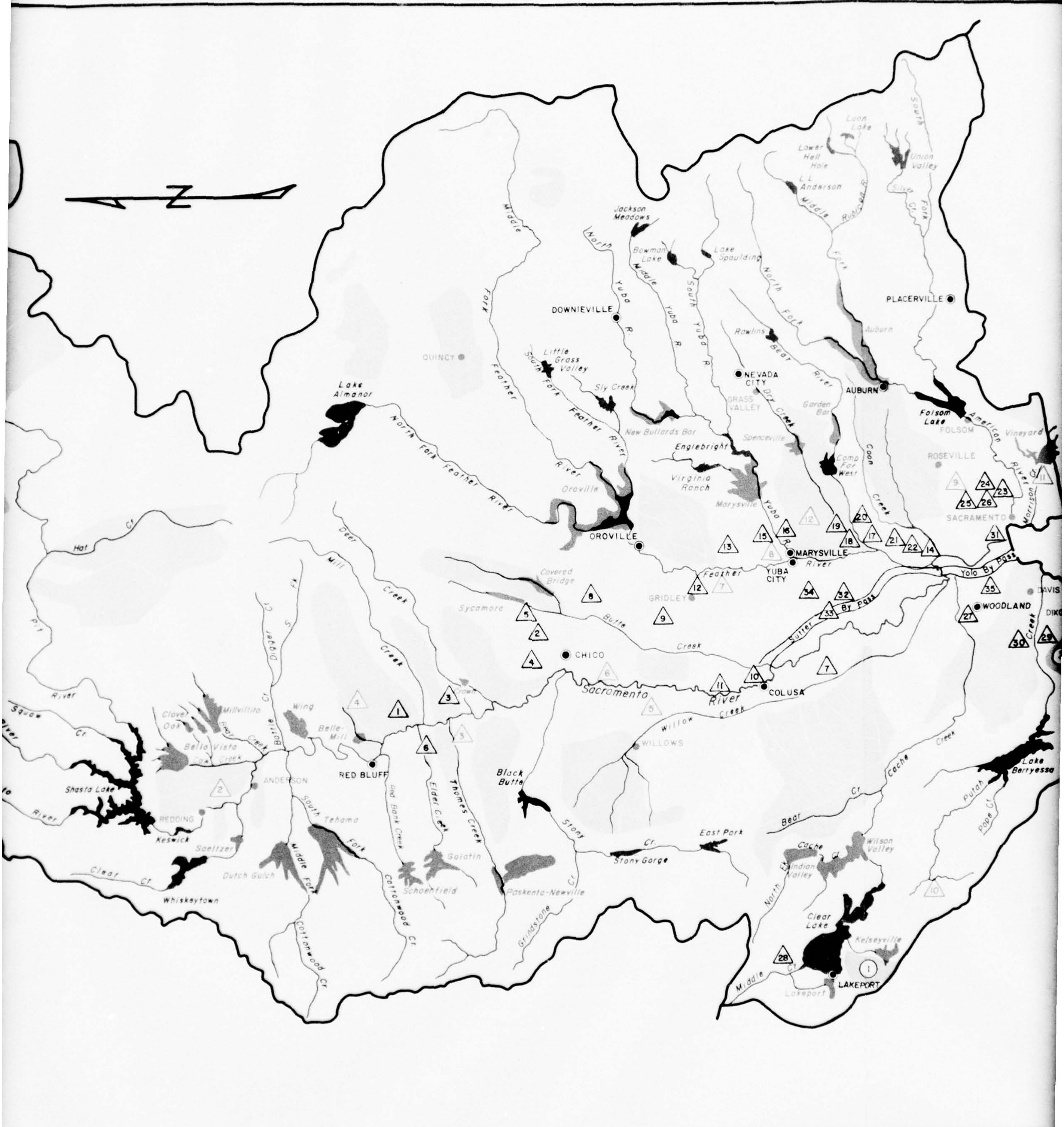


N
FEATHER RIVER BASIN
YUBA RIVER BASIN
AMERICAN RIVER BASIN
BEAR RIVER BASIN
COON CREEK STREAM GROUP
MORRISON CREEK GROUP
BUTTE BASIN AND TRIBUTARY STREAMS
PROJECT BYPASS IN SACRAMENTO BASIN
REDDING STREAM GROUP
MIDDLE SACRAMENTO RIVER TRIBUTARIES EASTSIDE
MIDDLE SACRAMENTO RIVER TRIBUTARIES WESTSIDE
COLUSA BASIN AND TRIBUTARY STREAMS
PUTAH CREEK BASIN
STONY CREEK BASIN
CACHE CREEK BASIN
REDDING STREAM GROUP
QUINCY
DOWNIEVILLE
NEVADA CITY
AUBURN
PLACERVILLE
OROVILLE
MARYSVILLE
YUBA CITY
Sacramento
WOODLAND
CHICO
COLUSA
WILLOWS
RED BLUFF
REDDING
LAKEPORT
Lake Almanor
Oroville
Folsom Lake
Shasta Lake
Keswick
Whiskeytown
Black Butte
Stony Gorge
East Park
Clear Lake
Lake Berryessa (Monticello Dam)
Englebright
Bullards Bar
Jackson Meadows
Bowman Lake
Lake Spaulding
Loon Lake
Lower Hell Hole
Union Valley
L.L. Anderson
Little Grass Valley
Sly Creek
Virginia Ranch
Rollins
Camp Far West
Yolo By Pass
Sutter By Pass
Sacramento River
Feather River

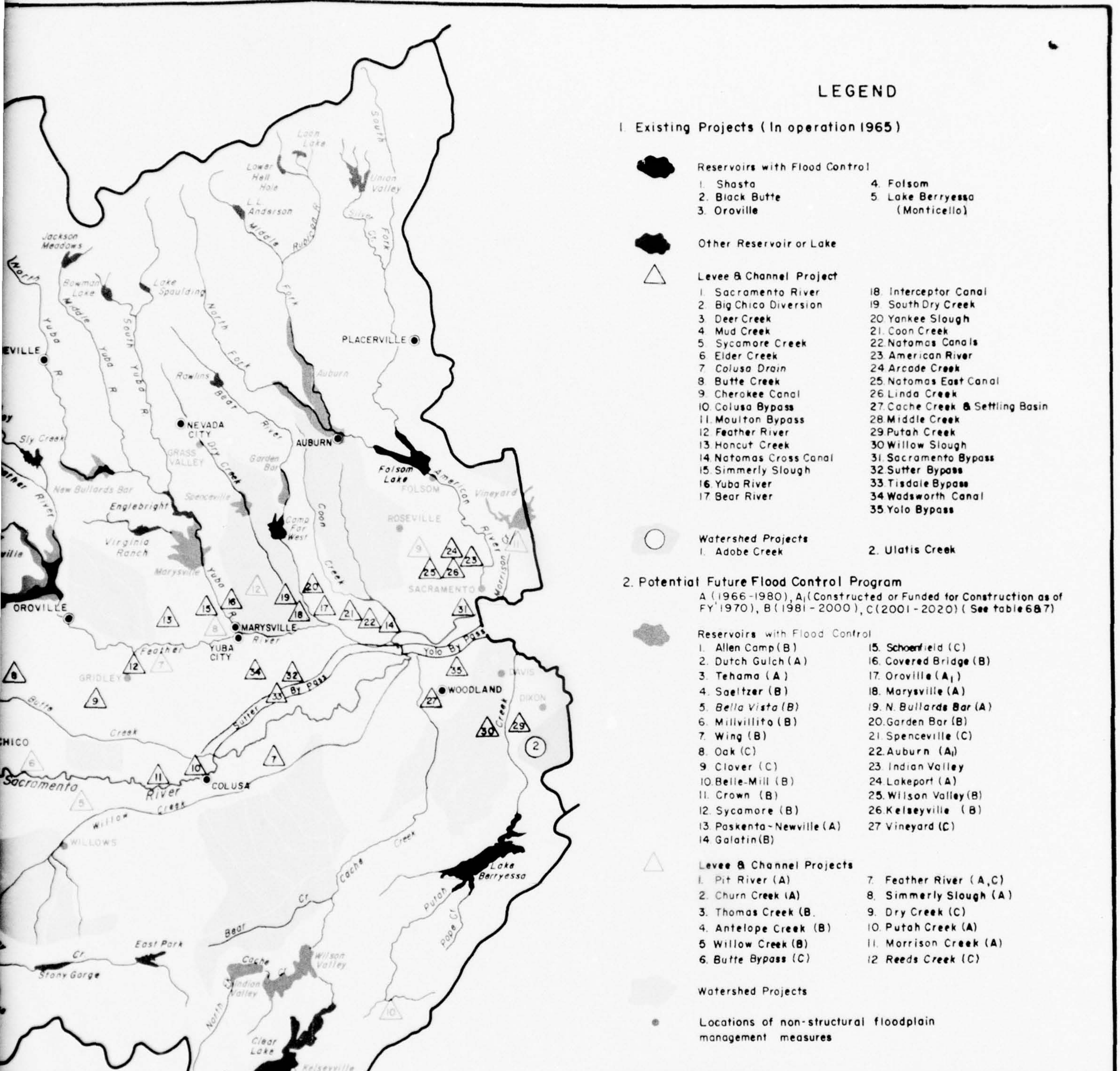


MAP 2
SACRAMENTO BASIN SUBREGION
CALIFORNIA REGION
FLOOD CONTROL STUDY AREAS

LAKEVIEW
Thomas
Cr
Cottonwood
Goose Lake
North Fork
Quartz Cr
Drews
Dog Lake
OREGON
CALIFORNIA
ALTURAS
South
Fork
Allen Camp
Pit River
Lake Almanor
Hat Cr
Deer
Mill
Pit
Digger Cr
S. Fk
McCloud
Mud Cr
River
Squaw
River
Cr
Clover Oak
Millvillita
Bear Creek
Battle
Wing
Belle-Mill
Bella Vista
Cow Creek
ANDERSON
RED BL
MT. SHASTA
Sacramento
DUNSMUIR
River
Shasta Lake
REDDING
Keswick
Soeltzer
South
Tehama
Fork
Middle Fork
Dutch Gulch
Clear Cr
Whiskeytown
Cottonwood Cr
HYDROLOGIC SUB-REGIONS
NC - NORTH COASTAL
SF - SAN FRANCISCO BAY
CC - CENTRAL COASTAL
SC - SOUTH COASTAL
SB - SACRAMENTO BASIN
DC - DELTA-CENTRAL SIERRA
SJ - SAN JOAQUIN BASIN
TB - TULARE BASIN
NL - NORTH LAHONTAN
SL - SOUTH LAHONTAN
CD - COLORADO DESERT



Jackson Meadows
Bowman Lake
Lake Spaulding
North
Middle
Yuba R.
South Yuba R.
North Fork
Loon Lake
Lower Hell Hole
L.L. Anderson
Middle
Rubicon R.
Union Valley
Silver
Fork
South
PLACERVILLE
DOWNIEVILLE
Middle Fork Feather River
QUINCY
Little Grass Valley
South Fork Feather River
Sly Creek
Lake Almanor
North Fork Feather River
NEVADA CITY
GRASS VALLEY
Rawlins
Bear River
Auburn
AUBURN
Folsom Lake
American River
FOLSOM
Vineyard
ROSEVILLE
SACRAMENTO
Morrison Cr
New Bullards Bar
Englebright
Virginia Ranch
Spenceville
Dry Creek
Garden Bar
Camp Far West
Coon Creek
Oroville
OROVILLE
Marysville
Yuba R.
MARYSVILLE
YUBA CITY
Feather River
Yolo By Pass
DAVIS
WOODLAND
Covered Bridge
Deer Creek
Mill Creek
Sycamore
Butte Creek
GRIDLEY
CHICO
Sutter By Pass
COLUSA
Sacramento River
Willow Creek
WILLOWS
Hat Cr
Pit River
Squaw Cr
Battle Cr
Bear Creek
Clover Oak
Bella Vista
Cow Creek
Wing
Belle-Mill
Shasta Lake
ANDERSON
REDDING
Keswick
Saeltzer
Clear Cr
Whiskeytown
Dutch Gulch
South Fork
Middle Fork
Tehama
RED BLUFF
Red Bank Creek
Elder Creek
Thomes Creek
Gallatin
Schoenfield
Cottonwood Cr
Paskenta-Newville
Grindstone Cr
Black Butte
Stony Cr
Stony Gorge
East Park
Bear Cr
Cache Creek
Lake Berryessa
Putah
Pope Cr
Wilson Valley
Indian Valley
Clear Lake
Kelseyville
Middle Cr
Lakeport
LAKEPORT



MAP 3
SACRAMENTO BASIN SUBREGION
CALIFORNIA REGION
FLOOD CONTROL PLAN

10 0 10 20
SCALE IN MILES

LAKEVIEW
Thomas
Cr
Cottonwood
Drews
Dog Lake
Quartz Cr
Goose Lake
OREGON
CALIFORNIA
North Fork
South Fork
ALTURAS
Pit
Allen Camp
River
Lake Almanor
Hat Cr
Pit River
Deer
Mill
Digger Cr
S. Fk
Battle Cr
Mud Cr
McCloud River
Squaw Cr
Oak
Millville
Bear
Clover
Cow Cr
Wing
1
2
3
4
5
6
Bella Vista
ANDERSON
REDDING
Shasta Lake
Keswick
MT. SHASTA
DUNSMUIR
Sacramento River
Whiskeytown
Clear Cr
Saeltzer
South Fork
Dutch Gulch
Cottonwood Cr
Tehama
Middle Fork
HYDROLOGIC SUB-REGIONS
NC - NORTH COASTAL
SF - SAN FRANCISCO BAY
CC - CENTRAL COASTAL
SC - SOUTH COASTAL
SB - SACRAMENTO BASIN
DC - DELTA CENTRAL SIERRA
SJ - SAN JOAQUIN BASIN
TB - TULARE BASIN
NL - NORTH LAHONTAN
SL - SOUTH LAHONTAN
CD - COLORADO DESERT
NC
NL
SB
SF
DC
SJ
TB
SL
CC
SC
CD

1.

2.

3.

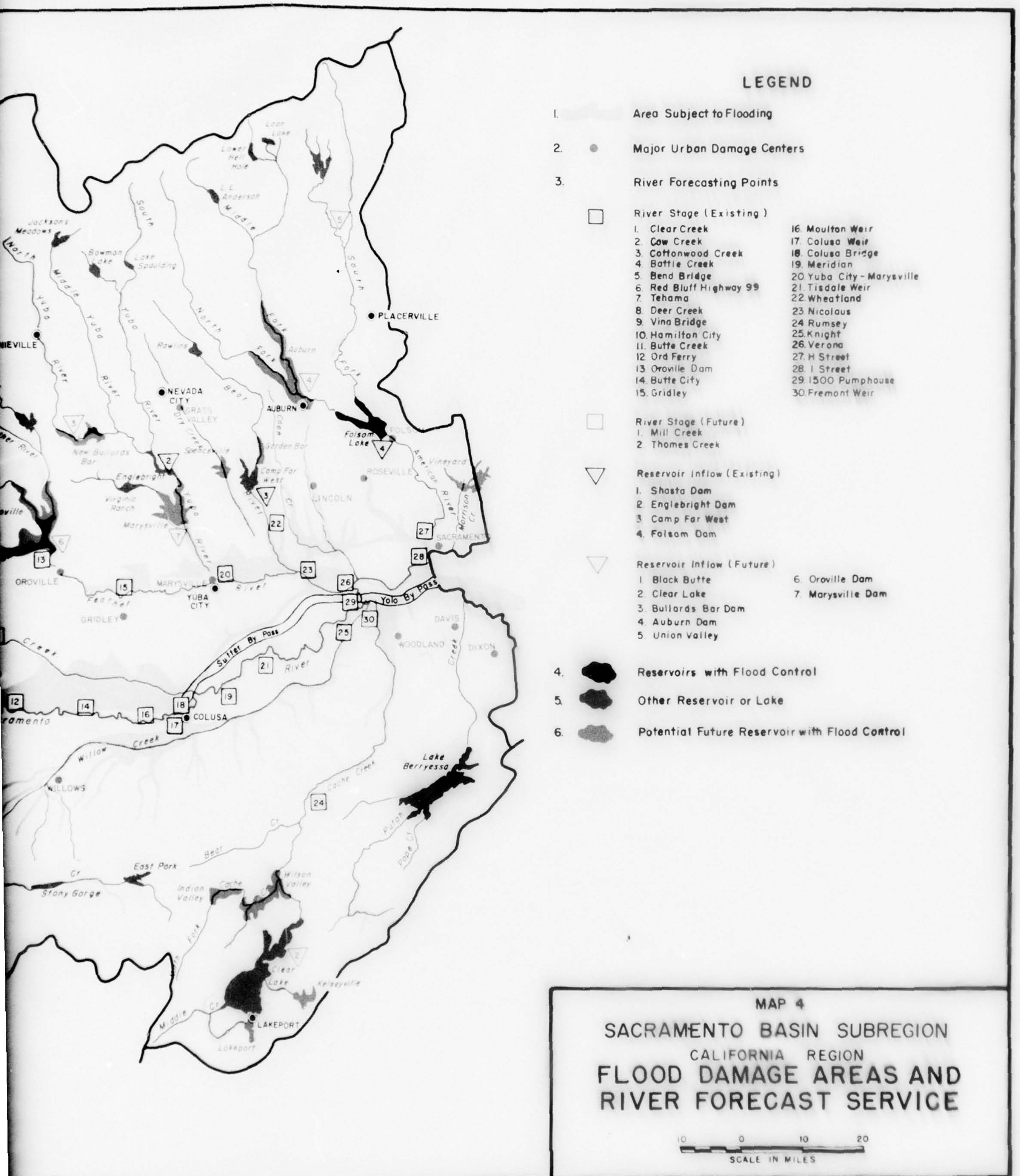
4.

5.

6.

SAC

FL
RIV



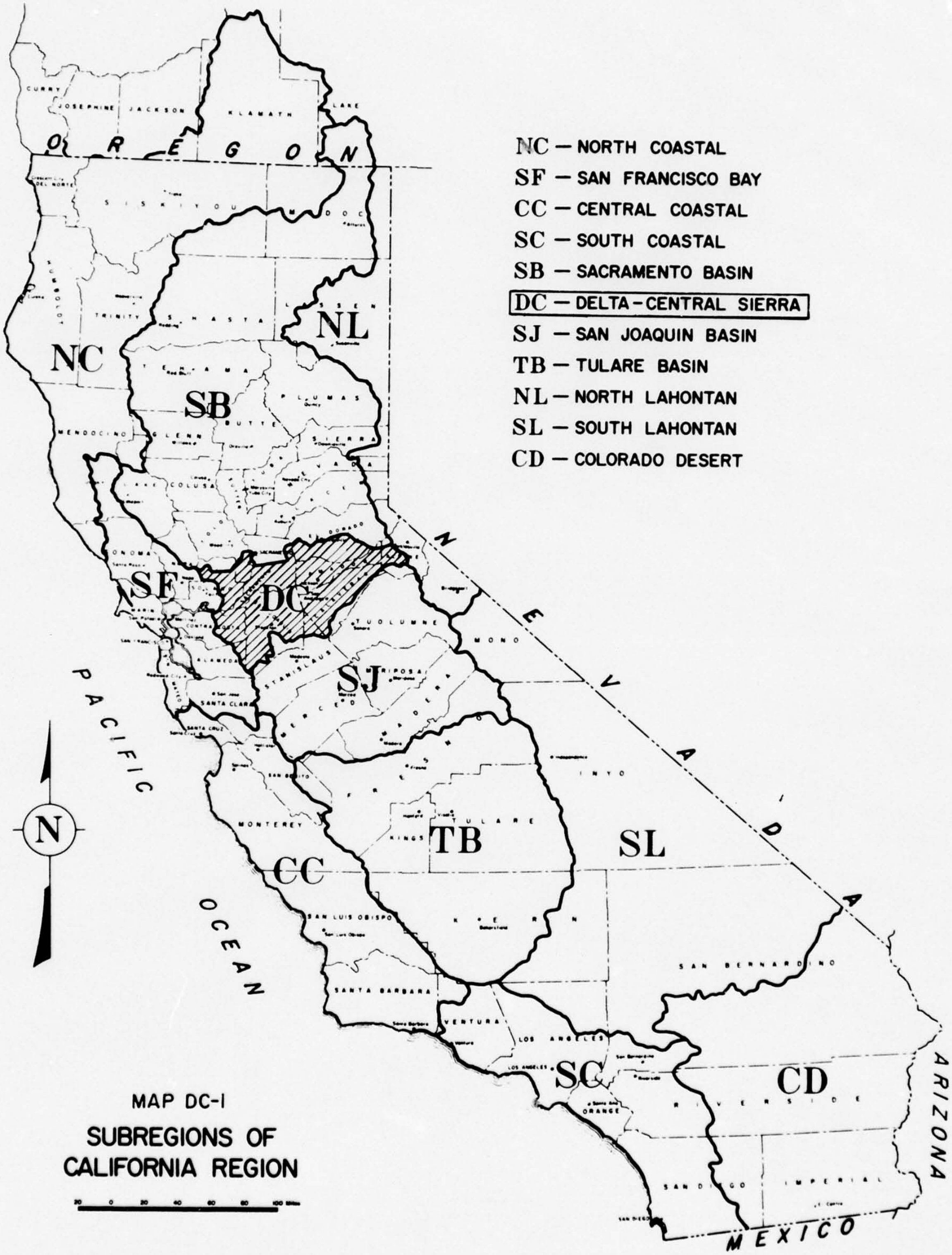
MAP 4

SACRAMENTO BASIN SUBREGION

CALIFORNIA REGION

FLOOD DAMAGE AREAS AND RIVER FORECAST SERVICE

DELTA-
CENTRAL
SIERRA
SUBREGION



MAP DC-1
SUBREGIONS OF CALIFORNIA REGION

DELTA-CENTRAL SIERRA SUBREGION

General

The Delta-Central Sierra Subregion (DC) is in central California. It extends generally from Sacramento on the north to Stockton on the south, and from the crest of the Sierra Nevada on the east to the foothills of the coastal ranges on the west. (See Map DC-1.) The subregion is about 120 miles long and 60 miles wide and comprises an area of 4,947 square miles.

The climate of the subregion is characterized by hot, dry summers and mild winters with relatively light precipitation in valley floor areas and by warm, dry summers and cold winters with heavy rain and snow in the mountainous areas. Average annual precipitation varies with elevation, ranging from less than 10 inches on the valley floor to over 96 inches in the Sierra Nevada. Temperatures on the valley floor normally range from winter lows near freezing to summer highs of about 110 degrees. Temperatures in the Sierra Nevada portion of the subregion range from below zero in the winter to about 80-90 degrees in the summer.

The subregion had an estimated population of 386,000 in 1965. Its economy is dominated by highly diversified agricultural and related manufacturing and industrial activities such as food processing and fabrication of agricultural machinery. The production of natural gas, clay and clay products, limestone, sand and gravel, and lumber and forest products are also significant economic activities.

Transportation facilities in the subregion are extensive. Highly developed Federal, State, and county highway and road systems afford ready access to all parts of the subregion and to adjoining areas. The area is served by air and rail lines and the Stockton and Sacramento Deep Water Ship Channels.

The Sacramento and San Joaquin Rivers are the principal streams in the Delta-Central Sierra Subregion and in the Central Valley of California. In general, Sacramento River drains a small area in the northwesterly sector of the subregion and San Joaquin River and some of its principal tributaries drain the remainder. The main tributary of Sacramento River in the subregion is Cache Slough. The bypass system of the Sacramento River Flood Control Project also has its terminus in this area. The principal tributaries of San Joaquin River in the subregion are the Cosumnes, Mokelumne, and Calaveras Rivers. (See Map 2.) All these streams drain into the Sacramento-San Joaquin Delta and to a common mouth at the upper end of Suisun Bay. The delta, a low-lying tidal area comprising about 500,000 acres of highly productive farmland, has been reclaimed by the construction of over 1,000 miles of levees along natural channels and dredge cuts that divide the area into about 100 tracts locally known as islands. Land surface elevations range from about 10 feet below sea level in the central portion of the delta to about 20 feet above sea level along the periphery.

Additional information on the subregion can be found in Appendix II, "The Region."

For the investigation of present and future flood problems and the analysis of potential solutions, the subregion has been divided into the following study areas: Cosumnes River Basin, Mokelumne River Basin, Stockton Area Streams, Westside Stream Group-Delta Central Sierra, Delta Islands, Cache Slough and Tributary Streams, Sacramento Deep Water Ship Channel and Project Bypasses in Delta Central Sierra, and Sacramento River below Sacramento.

History of Flooding

Floods have been a significant factor in the development of the subregion. Floods are of three types: 1) those that occur during the late fall and winter months, primarily as a result of prolonged general rainstorms in the mountain and valley floor areas; 2) those that occur during the spring and early summer months, primarily as a result of the melting of the winter snowpack in the high areas of the Sierra Nevada; and 3) those that occur in the Sacramento-San Joaquin Delta as the result of a combination of high tides, unfavorable wind conditions, and flood inflows. The most significant type is the late fall and winter flood caused by general rainstorms. A description of the greater floods of the late 1800's and early 1900's is included in the regional section of the appendix. On a subregional basis, the 1962-1963 flood is considered to be the most severe on the streams flowing from the west side of the subregion and the 1955-1956 flood the most severe flood on the streams flowing from the east side, although other floods may have caused higher flows on individual streams.

During a period of less than 72 hours in late December 1955, intense rainstorms in the mountain and valley floor areas of the subregion resulted in exceptionally large streamflows and subsequent flooding of adjacent lands. Snowmelt added about 1 inch of water to the basin mean runoff of about 15 inches. Unusually high tides aggravated the flood problem by impeding the passage of floodwaters through the Sacramento-San Joaquin Delta. Agricultural, public facility, and residential damages comprised over 90% of the total flood damage. Although no loss of life was reported as a result of the flood, over 4,000 people were evacuated from their homes. Subregion-wide, about 179,000 acres were inundated and flood damages exceeded $12.4 million.

Flood damages during the 1962-1963 flood was particularly serious along the streams flowing from the western part of the subregion. About 117,300 acres were inundated during the flood and total damages exceeded $2.0 million, over 90% of which were agricultural and public facility losses.

Flood fighting and cleanup costs under the various Federal programs exceeded $0.9 million for the 1955-1956 flood and about $0.1 million for the 1962-1963 flood. Damages from these and other significant, recent floods are tabulated as follows and are shown in more detail in Tables 1 and 2. Typical flood damages are shown in Photos DC-I and DC-II.

Serious rainfloods occurred in the Delta-Central Sierra Subregion during the 1968-1969 flood season. The floods resulted from precipitation ranging from 5 inches in the valley floor area to over 20 inches in the headwaters of the various streams. Over 63,500 acres were inundated with flood damage exceeding $15 million.

	Flood damages 1/ ($1,000)					
Flood season (year)	Forest & range resources & facilities	Agricultural & land	Residential & commercial	Industrial & utility	Public facilities	Total
1950-1951	150	3,123	41	170	2,485	5,969
1955-1956	790	6,010	1,745	265	3,655	12,465
1962-1963	0	1,619	90	26	325	2,060
1964-1965	940	1,840	42	91	3,849	6,762
1968-1969	21	6,234	405	7	8,436	15,103

1/ Based on prices and project and economic conditions at time of occurrence of flood.

Estimated damages from a 100-year frequency flood for selected streams in the subregion are shown in Table 3. Peak flows of maximum floods of record, 100-year floods, and standard project floods for selected stations in the subregion are shown in Table 11.

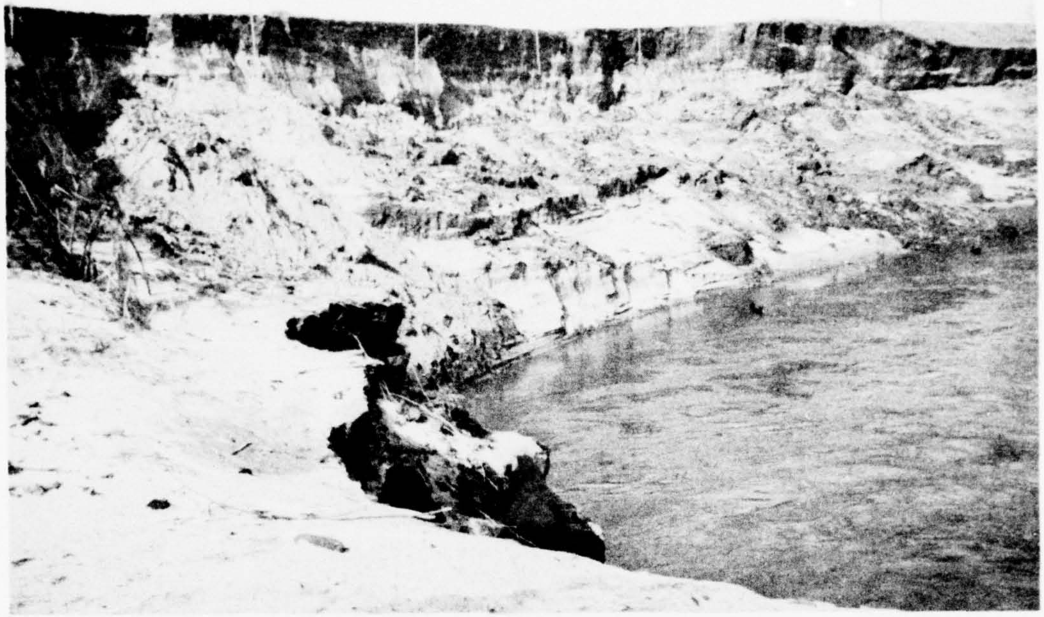
Present Status of Flood Control Improvements

The existing flood control improvements within the subregion include a variety of measures to reduce flood damages. (See Map 3.) They include flood forecasting, flood control reservoirs, floodwater retardation structures, levees and channels, tributary watershed treatment and flood plain information studies. Existing flood control measures on the Sacramento

and San Joaquin Rivers and their tributaries within the subregion and in other subregions provide flood protection to about 25% of the area subject to flooding. With a few exceptions, the degree of protection provided varies from 100-year or greater flood protection in urban areas, and from 10 to 50-year flood protection in agricultural areas.

Flood forecast procedures are established as an integral part of the existing flood control developments. The Federal-State River Forecast Center in Sacramento maintains continuous surveillance of flood situations issuing forecasts for the following: reservoir inflows; expected downstream flows and stages on the Sacramento, San Joaquin, Cosumnes and Mokelumne Rivers; and, stages in the Sacramento-San Joaquin Delta. The below-sea-level islands in this area are subject to flooding during periods of high inflow from the area's tributaries, particularly when the inflow occurs in conjunction with high tides and strong southerly or southwesterly winds. Flood forecasts have been developing in an effort to gain valuable time to protect the levees. The key forecast point is Rio Vista with stages throughout the Delta referenced thereto. Forecasting points are shown on Map 4.

Major flood control reservoirs in the subregion are operated to provide a maximum of 417,000 acre-feet of flood control storage during the most critical flood situations. These projects are as follows:



Levee erosion along Cosumnes River, December 1964. (Corps of Engineers Photo.)

PHOTO DC-I

Break in the east levee of San Joaquin River near Mossdale, 1950 flood. (Corps of Engineers Photo.)

PHOTO DC-II

Sherman Island (left of levee road) after levee failure during January 1969. About 10,000 acres were flooded. (Corps of Engineers Photo.)

PHOTO DC-III

Sherman Island flooding and debris, January 1969. (Bureau of Reclamation Photo.)

PHOTO DC-IV

Reservoir	Stream	Flood control capacity (ac.-ft.)	Drainage area (sq. miles)
Mokelumne River Basin			
Camanche	Mokelumne River	200,000	613
Stockton Area Streams			
New Hogan	Calaveras River	165,000	363
Farmington	Littlejohns Creek	52,000	212

These projects are shown on Map 3. New Hogan Reservoir is shown in Photo DC-V.

Many reservoirs in the subregion, though not having flood control as a designated function, provide incidental but often significant flood control benefits. Principal reservoirs of this type are:

Reservoir	Stream	Construction agency
Pardee	Mokelumne River	East Bay Municipal Utility District
Salt Springs	N. Fork Mokelumne R.	Pacific Gas and Electric Company
Jenkinson Lake (Sly Park Dam)	Sly Park Creek	Bureau of Reclamation

An extensive system of 1,545 miles of flood control levees, channels and bypasses is an important element in the overall flood control program of the Delta-Central Sierra Subregion. Most of this integrated, continuous system is part of the Sacramento River Flood Control Project, a Federal-non-Federal and private undertaking. A portion of this system is shown in Photo DC-VI. However, a significant segment of the Lower San Joaquin River and Tributaries Project is also located in the subregion. These features are indicated on Map 3 and data concerning the existing (1965) levee and channel projects are contained in Table 7. In addition to the principal levee and channel systems, local interests have constructed numerous secondary levees and improved channels. These secondary improvements primarily to agricultural areas, vary in quality and provide varying degrees of protection. In general, the protection afforded ranges from a once-in-2-year flood to a once-in-25-year flood.

Three watershed projects have been constructed to alleviate watershed problems. They are: 1) Ulatis Creek Project near Vacaville, 2) Marsh-Kellogg Project near Brentwood, and 3) Mosher Creek Project near Stockton. These projects protect 44,720 acres of prime agricultural lands from 10 to 50-year floods. Flood prevention measures in other tributary watershed areas of the subregion have been installed by individual landowners, groups of farmers and ranchers and Federal and State land-management agencies.

The Flood Plain Management Services Program is covered in detail in the Regional Summary of this appendix. Flood plain information reports on lower Cosumnes River and tributaries, Morrison Creek Stream Group and the Snodgrass Slough area have been completed for parts of Sacramento and San Joaquin Counties. Under the program, flood hazard information is being furnished to local agencies for use in evaluating the flood hazard of individual site locations. The counties have requested assistance in implementing zoning and in specific interpretation of flood hazard information as it applies to site development.

Accomplishments of the existing flood control measures (and others that provide incidental flood control benefits) have been substantial. The measures have functioned effectively to reduce floodflows and flood damage. The flood control system existing in 1965 would have prevented $4.5 million in flood damages during the 1950-1951 flood; $5.0 million in flood damages during the 1955-1956 flood; and, $4.0 million in flood damages during the 1964-1965 flood. Additional details are included in Table 2. It is estimated that average annual damages prevented by existing measures exceeds $3.2 million.

Although the subregion currently is afforded a considerable degree of flood protection, flood problems still exist in some areas. Flooding occurs along some of the streams in the area with resulting damages to agricultural and urban properties. (See tabulation, Page DC-7). The problems are especially serious along Sacramento River below the city of Sacramento and in the Cosumnes River Basin, Westside Stream Group, Cache Slough and Delta Islands study areas.

Erosion presents a problem in the Delta-Central Sierra Subregion. Of the 1,980 miles of stream channels subject to erosion, about 830 miles are classed as "serious", accounting for $50,000 damages annually. Erosion in the Delta is caused primarily by wave action generated by high winds, high tides and wavewash from boats, or a combination of these. In terms of potential erosion damage, land loss and depreciation in productivity of adjacent agricultural land from stream bank erosion pose the greatest threat. Currently, about 30 acres of land are lost annually with about 10 acres occurring in urban areas. (See Tables 1, 3 and 4 for various categories of flood damages some of which index the magnitude of the problem of land and erosion damage.)

New Hogan Dam and Reservoir on Calaveras River. (Corps of Engineers Photo.)

PHOTO DC-V

Yolo Bypass and the Interstate 80 crossing (Yolo Causeway) during the December 1964 flood. (Department of Water Resources Photo.)

PHOTO DC-VI

Much of the flood problem in tributary watershed areas has not been alleviated. Less than 10% of the tributary areas are receiving flood protection and this is often limited.

The aforementioned flood problems result in average annual damages as follows:

Study area	Estimated Average Annual Damages ($1,000) 1/
Cosumnes River Basin	717
Mokelumne River Basin	276
Stockton Area Streams	355
Westside Stream Group- Delta Central Sierra	227
Delta Islands	2,150
Cache Slough & Tributary Streams	841
Sacramento Deep Water Ship Channel and Project Bypass in DC	285
Sacramento River below Sacramento	856
Total Delta-Central Subregion	5,707

1/ Based on 1965 prices, economic conditions, and project conditions.

Additional details are contained in Tables 3 and 4 for the subregion as a whole and in Table 9 for urban areas. Major urban damage centers and areas of the subregion subject to flooding are shown on Map 4.

Future Needs

It is evident from an examination of 1965 flood problems that additional flood control measures are required. It is estimated that average annual flood damages in the Delta-Central Sierra Subregion (based on 1965 prices and conditions) amount to $5.7 million. The flood problems of the area will increase in the future due to the pressures of population and economic growth and resultant increases in use of flood plains. The population of the subregion is projected to increase from 386,000 in 1965 to 530,000 in 1980, 985,000 in 2000, and 1,981,000 in 2020. Average annual flood damages are expected to increase to $7.9 million by 1980, to $14.8 million by 2000, and $34.9 million by 2020 if additional flood control measures are not provided. Estimated damage data for existing and future conditions are contained in Tables 5 and 9a.

Measures Required to Satisfy Future Needs

Improved flood forecasting will be a part of a comprehensive flood control program. The optimum operation of flood control projects can only be approached by a well-coordinated system of forecasting and project operation. Hence, procedural development for forecasts of inflow to reservoirs will be required as new dams and levees are built. Additional hydrologic instrumentation and telemetry systems will be needed to facilitate these forecasts and subsequent operation of the projects. Flow forecasts in the Delta will become increasingly more important with expanding port development, agricultural usage, and urbanization. Large scale water diversion and related salt water intrusion will also require long-range and short-range flow forecasts. The cost of improving the flood forecasting system is estimated to cost $760,000 for the 1966-1980 period, $250,000 for the 1981-2000 period, and $250,000 for the 2001-2020 period.

Floodwater storage in reservoirs and detention structures will be an important element of the future flood control program. An additional 621,000 acre-feet of flood control capacity are required in the subregion to satisfy future needs as shown in the following tabulation:

Study area/ program period in which needed	Reservoir	Stream	Flood control capacity (ac.-ft.)	Drainage area (sq. miles)
Cosumnes River Basin				
1966-1980	County Line	Deer Creek	15,000	40
1966-1980	Nashville	Cosumnes River	200,000	435
1966-1980	Detention Structures (3)	(Various)	7,000	89
2001-2020	Latrobe	Cosumnes River	150,000	530
Mokelumne River Basin				
1981-2000	Hutson School	Dry Creek	100,000	283
2001-2020	Irish Hill	Dry Creek	35,000	79
2001-2020	Detention Structures (2)	(Various)	14,000	120
Stockton Area Streams				
2001-2020	South Gulch	Calaveras River	35,000	418
2001-2020	Eugene	Littlejohn Creek	50,000	83

Study area/ program period in which needed	Reservoir	Stream	Flood control capacity (ac.-ft.)	Drainage area (sq. miles)
Westside Stream Group				
1966-1980	Kellogg	Kellogg Creek	8,000	27
1981-2000	Detention Structures (3)	(Various)	6,000	59
Cache Slough and Tributary Streams				
1981-2000	Detention Structures (2)	(Various)	1,000	30
		TOTAL	621,000	

These reservoirs are shown on Map 3. Additional information on flood control storage is contained in Table 6. Estimated costs for additional flood control capacity are estimated at $15.4 million for the 1966-1980 period, $9.0 million for the 1981-2000 period, and $14.5 million for the 2001-2020 period.

In some areas, limited capacities of downstream channels will require associated levee and channel work to pass project releases safely. In the Delta substandard levee sections must be improved and the total levee system upgraded. Preliminary studies indicate that levee and channel work is desirable in the following areas of the Delta-Central Sierra Subregion:

Study area	Levees (Bank Miles)	Channels (Miles)
Cosumnes River Basin		
1966-1980	46	33
2001-2020	48	20
Mokelumne River Basin		
1966-1980	12	6
1981-2000	14	7
2001-2020	3	5
Stockton Area Streams 1/		
1966-1980	12	61
2001-2020	35	20

Study area	Levees (Bank Miles)	Channels (Miles)
Westside Stream Group-Delta-Central Sierra		
1966-1980	0	12
Delta Islands		
1966-1980	25	0
1981-2000	130	0
2001-2020	130	0
Cache Slough and Tributary Streams		
1981-2000	4	18
Sacramento River below Sacramento		
1981-2000	70	0
2001-2020	140	0
TOTAL	669	182

1/ Under construction or funded for construction as of FY 1970.

The approximate locations of levees and channels are indicated on Map 3. Additional details are included in Table 7. The estimated costs for required levee and channel work are $21.0 million for the 1966-1980 period, $50.4 million for the 1981-2000 period, and $63.0 million for the 2001-2020 period.

The structural measures included in the preceeding paragraph will be complemented by non-structural land treatment measures consisting primarily of range seeding, critical area planting, drop inlets, fire prevention and suppression and brush control. See Map 3 for potential watershed land treatment areas. Estimated costs and acres of land treatment measures are tabulated below.

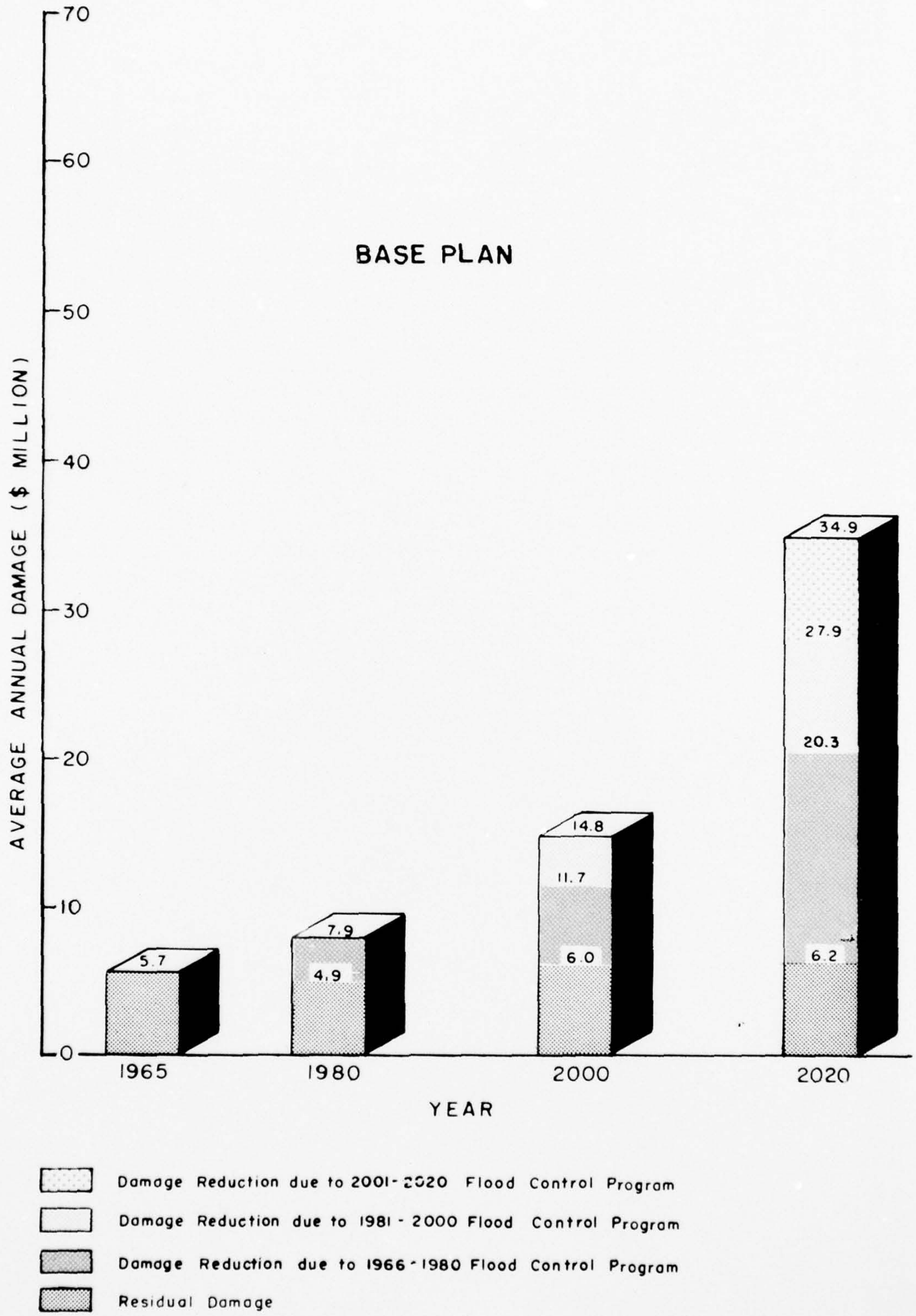
Land Treatment	1966-1980	1981-2000	2001-2020
Thousand acres	70	17	25
Thousand dollars	390	850	500

Flood plain zoning, flood proofing and other non-structural flood plain management measures will become part of community flood control planning because of existing and anticipated flood problems. Communities with populations in excess of 2,500 with known significant flood problems include Antioch, Lodi, Stockton, Vacaville, Tracy, and Brentwood. Many communities with expanding populations are expected to have flood problems in the future, and will be studied as their needs are made known. Flood plain information reports for Calaveras and Mokelumne Rivers, including the principal urban areas of Lodi and Stockton, are scheduled for completion by 1980. It is anticipated that flood plain information reports for all the communities named above will be completed before the year 2000. Comprehensive flood damage prevention planning and implementation of flood plain management measures would follow in each flood problem area identified. Non-structural flood plain management measures along approximately 50 stream miles could be implemented for urban areas, including the above listed communities. Table 9b contains data of damage reduction attributable to non-structure measures. Map 3 indicates several areas for which non-structural flood plain management measures are proposed.

Costs for future non-structural flood plain management measures are estimated at $1.2 million for the 1966-1980 period, $3.0 million for the 1981-2000 period, and $12.0 million for the 2001-2020 period.

Potential to Satisfy Future Needs

The flood control program presented herein would reduce the projected average annual damages $3.0 million by 1980, $8.8 million by 2000, and $28.7 million by 2020 at an estimated installation cost of $38.8 million for the period 1966-1980, $63.5 million for 1981-2000, and $90.3 million for 2001-2020. Estimated annual OM&R costs for the 1966-1980, 1981-2000 and 2001-2020 portion of the flood control program are $0.46 million, $0.74 million and $0.98 million (See Tables 10, 10a and 10b.) The effect of the potential flood control program on future damages is shown in Table 8 and graphically on Figure DC-1, and its effect on flood flows is shown on Table 11.



CALIFORNIA REGION
COMPREHENSIVE FRAMEWORK STUDY

PROJECTED AVERAGE ANNUAL FLOOD DAMAGES
(1965 PRICES AND PROJECT CONDITIONS-DATA FROM TABLES 5 & 8)

APPENDIX IX

FIGURE DC-1

TABLE 1

DELTA-CENTRAL SIERRA SUBREGION OF THE CALIFORNIA REGION

Historical Flood Data

Study area	Flood	Location/ flow (cfs)	Area inundated (1,000 acres)	Flood damages 1/ - ($1,000): Forest & range resources	Forest & range facilities	Crop & pasture	Other agricultural	Land	Residential & commercial	Industrial & utility	Public facilities	Total
1	2	3	4	5	6	7	8	9	10	11	12	13
Cosumnes River Basin	Dec55	Michigan Bar 42,000	42.4	0	486	459	651	268	12	41	378	2,295
	Apr58	Michigan Bar 29,300	32.1	0	207	320	442	178	13	37	380	1,577
Mokelumne River Basin	Nov50	Camanche 26,700	19.4	0	150	558	123	12	82	491	299	1,715
	Dec55	Camanche 25,500	31.5	0	225	755	222	30	9	139	318	1,698
Stockton Area Streams	Dec55	Hogan Inflow 31,000 (Outflow 11,100)	9.1	0	79	139	38	6	1,580	101	518	2,461
	Jan-Apr 58	Hogan Inflow 42,000 (Outflow 11,000)	13.7	0	92	413	25	18	190	37	409	1,184
Westside Stream Group - Delta-Central Sierra	Dec58 2/	Marsh Creek 3,400	10.6	0	0	242	35	12	26	0	30	345
	Jan63	Marsh Creek 3,900	11.3	0	0	216	63	24	90	0	43	436
Delta Islands	Dec50	Vernalis 79,000	57.0	0	0	1,743	421	477	78	0	2,187	4,906
Cache Slough and Tributary Streams	Apr58	Unknown	20.0	5	0	294	79	50	3	1	257	689
Sacramento Deep Water Ship Channel and Project Bypasses in D.C.	Mar07	Lisbon Gage 428,000					No Damage Data					
	Dec64	Lisbon Gage 370,000	59.6	0	0	693	0	0	0	17	1,700	2,410
Sacramento River below Sacramento	Dec55	Rio Vista 9.8 (ft.)	1.0	0	0	2	8	0	108	10	474	602
	Dec64	Rio Vista 8.9 (ft.)	0.3	0	0	0	0	0	42	12	135	189

1/ Data based on prices and project and economic conditions at time of occurrence of flood.
2/ Flood damages for all streams in group for which damage data was available.

TABLE 2

DELTA-CENTRAL SIERRA SUBREGION OF THE CALIFORNIA REGION

Flood Damage 1/

Study area	Flood	Location/ flow (cfs)	Total damages - ($1,000)					
			At time of flood 2/			1965 economic conditions & prices 3/		
			Actual damage	Damage without flood control projects	Damage prevented by flood control projects 4/	Damage with 1965 project conditions	Damage without flood control projects	Damage prevented by 1965 projects 5/
1	2	3	4	5	6	7	8	9
Cosumnes River Basin	Dec55	Michigan Bar 42,000	2,295	2,295	0	2,955	3,095	140 6/
Mokelumne River Basin	Nov50	Camanche 26,700	1,715	1,715	0	1,061	2,759	1,698
Stockton Area Streams	Jan-Apr 58	Hogan Inflow 42,000 (Outflow 11,000)	1,184	19,516	18,332	592	32,118	31,526
Westside Stream Group - Delta-Central Sierra	Jan63	Marsh Creek 3,900	436	515	79	271	599	328
Delta Islands	Dec50	Vernalis 79,000	4,906	4,906	0	14,575	23,350	8,775
Cache Slough and Tributary Streams	Apr58	Unknown	689	689	0	422	872	450
Sacramento Deep Water Ship Channel and Project Bypasses in D.C.	Dec64	Lisbon Gage 370,000	2,410	7/	0	2,410	7/	0
Sacramento River below Sacramento	Dec64	Rio Vista 8.9 (ft.)	189	10,189	10,000	189	10,189	10,000

1/ Maximum flood for which data are available.
2/ Data based on prices and project and economic conditions at time of occurrence of flood.
3/ Data based on recurrence of original flood.
4/ Column 6 = column 5 - column 4.
5/ Column 9 = column 8 - column 7.
6/ Flood damage reduction in Cosumnes "pool" area creditable to Camanche Reservoir.
7/ The Project Bypasses prevent damages to the Sacramento River below Sacramento and the damages prevented are assigned to Sacramento River below Sacramento. Principal damages are to flowage easement areas in the Bypasses and sedimentation in the navigable channels.

TABLE 3

DELTA-CENTRAL SIERRA SUBREGION OF THE CALIFORNIA REGION

Estimated Flood Damage for
the 100-Year Frequency Flood 1/
for Selected Streams

Study area/ stream	Area inundated (1,000 acres)	Flood damage 2/ - ($1,000) Forest & range resources	Forest & range facilities	Crop & pasture	Other agricultural	Land	Residential & commercial	Industrial & utilities	Public facilities	Total
1	2	3	4	5	6	7	8	9	10	11
Cosumnes River Basin Cosumnes River	56.6	0	607	935	1,299	648	26	82	558	4,155
Mokelumne River Basin Mokelumne River	28.5	0	564	288	120	139	76	46	115	1,348
Stockton Area Streams Calaveras River	20.6	0	140	528	142	24	3,460	243	1,133	5,670
Westside Stream Group-Delta-Central Sierra Marsh-Kellogg Creeks	19.6	0	0	302	431	187	266	69	75	1,330
Delta Islands Lower San Joaquin River	181.0	0	0	18,949	7,276	7,265	1,184	0	23,926	58,600
Cache Slough and Tributary Streams Ulatis Creek	119.8	15	0	939	345	226	429	898	910	3,762
Sacramento Deep Water Ship Channel and Project By-passes in D.C. Yolo Bypass	64.0	0	0	778	0	0	0	19	1,903	2,700
Sacramento River below Sacramento Sacramento River	86.3	0	0	23,500	12,000	700	38,400	5,000	6,000	85,600

1/ See Table 11 for magnitude of 100-year flood at selected stations.
2/ Based on July 1965 prices, economic conditions, and project conditions.

TABLE 4

DELTA-CENTRAL SIERRA SUBREGION OF THE CALIFORNIA REGION

Estimated Average Annual Flood Damage

Study area (principal stream)	Flood damage 1/ - ($1,000) Forest & range resources	Forest & range facilities	Crop & pasture	Other agricultural	Land	Residential & commercial	Industrial & utilities	Public facilities	Study area totals
1	2	3	4	5	6	7	8	9	10
Cosumnes River Basin (Cosumnes River)	0	151	156	193	109	5	12	91	717
Mokelumne River Basin (Mokelumne River)	0	135	42	20	24	19	13	23	276
Stockton Area Streams (Calaveras River)	0	25	61	16	3	179	11	60	355
Westside Stream Group - Delta-Central Sierra (Marsh-Kellogg Creeks)	0	0	36	102	46	30	7	6	227
Delta Islands (San Joaquin River)	0	0	636	307	288	36	0	883	2,150
Cache Slough and Tributary Streams (Ulatis Creek)	3	0	328	106	70	56	138	140	841
Sacramento Deep Water Ship Channel and Project Bypasses in D.C. (Yolo Bypass)	0	0	83	0	0	0	3	199	285
Sacramento River below Sacramento (Sacramento River)	0	0	235	120	7	384	50	60	856
Total Delta-Central Sierra Subregion	3	311	1,577	864	547	709	234	1,462	5,707

1/ Damages based on July 1965 prices, economic conditions, and project conditions.

TABLE 5

DELTA-CENTRAL SIERRA SUBREGION OF THE CALIFORNIA REGION

Summary of Estimated Average Annual Flood Damage for Present and Future Conditions of Economic Development with Existing Flood Control Measures

Study area (principal stream)	Average annual flood damages 1/ - ($1,000)			
	1965 economic conditions 2/	1980 economic conditions	2000 economic conditions	2020 economic conditions
1	2	3	4	5
Cosumnes River Basin (Cosumnes River)	717	934	1,399	2,239
Mokelumne River Basin (Mokelumne River)	276	342	519	999
Stockton Area Streams (Calaveras River)	355	560	1,320	3,975
Westside Stream Group-Delta-Central Sierra (Marsh Creek)	227	317	540	1,167
Delta Islands (San Joaquin River)	2,150	2,946	5,840	14,640
Cache Slough and Tributary Streams (Ulatis Creek)	841	1,013	1,657	3,040
Sacramento Deep Water Ship Channel and Project Bypasses in D.C. (Yolo Bypass)	285	311	395	645
Sacramento River below Sacramento (Sacramento River)	856	1,443	3,107	8,193
Total Delta-Central Sierra Subregion	5,707	7,866	14,777	34,898

1/ Damages based on July 1965 prices and project conditions, and estimated economic conditions for the year shown.
2/ Figures in column 2 are from column 10 of Table 4.

TABLE 6

DELTA-CENTRAL SIERRA SUBREGION OF THE CALIFORNIA REGION

Summary of Flood Control Capacity for Existing and Future Reservoirs

Study area	Flood control capacity 1/ - (1,000 ac-ft)				
	Existing projects (1965)	Projects 1966-1980 2/	Projects 1981-2000 2/	Projects 2001-2020 2/	Total projects as of 2020
1	2	3	4	5	6
Cosumnes River Basin	0	222	0	150	372
Mokelumne River Basin	200	0	100	49	349
Stockton Area Streams	217	0	0	85	302
Westside Stream Group - Delta-Central Sierra	5	8	6	0	19
Cache Slough and Tributary Streams	0	0	1	0	1
Total Delta-Central Sierra Subregion	422	230	107	284	1,043

1/ Maximum flood control capacity. Does not include surcharge storage.
2/ Includes only reservoirs controlling the 100-year flood, or better, at the damsite above urban areas and reservoirs controlling at least the 10-year flood at the damsite where only rural areas are to be protected.

TABLE 7

DELTA-CENTRAL SIERRA SUBREGION OF THE CALIFORNIA REGION

Summary of Levee and Channel Flood Protection Projects
- Existing and Future -

Study area	Levee and channel projects									
	Existing projects (1965)		Projects 1966-1980 1/		Projects 1981-2000 1/		Projects 2001-2020 1/		Total projects as of 2020	
	Levees (miles)	Channels (miles)	Levees (miles)	Channels (miles)	Levees (miles)	Channels (miles)	Levees (miles)	Channels (miles)	Levees (miles)	Channels (miles)
1	2	3	4	5	6	7	8	9	10	11
Cosumnes River Basin	0	0	46	33	0	0	48	20	94	53
Mokelumne River Basin	38	22	12	6	14	7	3	5	67	40
Stockton Area Streams	55	38	12	61	0	0	35	20	102	119
Westside Stream Group-Delta-Central Sierra	0	11	0	12	0	0	0	0	0	23
Delta Islands	60	0	25	0	130	0	130	0	345	0
Cache Slough and Tributary Streams	36	64	0	0	4	18	0	0	40	82
Sacramento Deep Water Ship Channel and Project Bypasses in D.C.	48	0	0	0	0	0	0	0	48	0
Sacramento River below Sacramento	1,173	0	0	0	70	0	140	0	1,383	0
Total Delta-Central Subregion	1,410	135	95	112	218	25	356	45	2,079	317

1/ Includes only projects giving 100-year flood protection, or better, to urban areas and at least 10-year flood protection to agricultural areas.

TABLE 8

DELTA-CENTRAL SIERRA SUBREGION OF THE CALIFORNIA REGION

Estimated Average Annual Flood Damage and Damage Reduction
- Present and Future Economic Conditions -

Study area (principal stream)	Total damages - 1965 prices ($1,000)									
	1965 economic & project conditions 1/	1980 economic conditions			2000 economic conditions			2020 economic conditions		
		W/1965 project conditions 2/	Reduction in damages due to 1966-1980 flood control program 3/	Residual damage W/ 1966-1980 program 4/	W/1966-1980 program	Reduction in damages due to 1981-2000 flood control program 3/	Residual damage W/ 1981-2000 program 5/	W/1981-2000 program	Reduction in damages due to 2001-2020 flood control program 3/	Residual damage W/ 2001-2020 program 6/
1	2	3	4	5	6	7	8	9	10	11
Cosumnes River Basin (Cosumnes River)	717	934	703	231	329	38	291	444	298	146
Mokelumne River Basin (Mokelumne River)	276	342	10	332	482	199	283	466	215	251
Stockton Area Streams (Calaveras River)	355	560	448	112	313	71	242	833	440	393
Westside Stream Group-Delta-Central Sierra (Marsh Creek)	227	317	2	315	538	158	380	616	38	578
Delta Islands (San Joaquin River)	2,150	2,946	1,823	1,123	2,246	833	1,413	3,533	2,047	1,486
Cache Slough and Tributary Streams (Ulatis Creek)	841	1,013	0	1,013	1,657	411	1,246	2,061	400	1,661
Sacramento Deep Water Ship Channel and Project Bypasses in DC (Yolo Bypass)	285	311	0	311	395	0	395	645	0	645
Sacramento River below Sacramento (Sacramento River)	856	1,443	0	1,443	3,107	1,359	1,748	4,615	3,599	1,016
Total Delta-Central Sierra Subregion	5,707	7,866	2,986	4,880	9,067	3,069	5,998	13,213	7,037	6,176

1/ Figures shown in column 2 are from column 10 of Table 4 and are also shown in column 2 of Table 5.
2/ Figures in column 3 are from column 3 of Table 5.
3/ Includes structural and non-structural measures.
4/ Column 5 = column 3 - column 4.
5/ Column 8 = column 6 - column 7.
6/ Column 11 = column 9 - column 10.

TABLE 9

DELTA-CENTRAL SIERRA SUBREGION OF THE CALIFORNIA REGION

Estimated Average Annual Flood Damage for Urban Areas with Significant Flood Problems

Study area/ stream	Damage center	Average annual flood damages ($1,000) 1/ Residential	Commercial	Industrial & utilities	Public facilities	Total
1	2	3	4	5	6	7
Mokelumne River Basin						
Mokelumne River	Lodi	10	3	1	7	21
Stockton Area Streams						
Calaveras River	Stockton	122	30	9	29	190
Westside Stream Group-Delta-Central Sierra						
Marsh-Kellogg Creeks	Brentwood	7	22	4	1	34
Corral Hollow	Tracy	0	0	1	4	5
Delta Islands						
Lower San Joaquin River	Antioch	1	4	0	4	9
Cache Slough and Tributary Streams						
Ulatis Creek	Vacaville	15	5	10	10	40
Total Delta-Central Subregion		155	64	25	55	299

1/ Damages are based on July 1965 prices, economic conditions, and project conditions.

TABLE 9a

DELTA-CENTRAL SIERRA SUBREGION OF THE CALIFORNIA REGION

Summary of Estimated Average Annual Flood Damage for Urban Areas with Significant Flood Problems
- Present and Future Conditions of Economic Development
with Existing Flood Control Measures -

Study area/ stream	Damage center	Average annual flood damages 1/ - ($1,000) 1965 economic conditions 2/	1980 economic conditions	2000 economic conditions	2020 economic conditions
1	2	3	4	5	6
Mokelumne River Basin					
Mokelumne River	Lodi	21	36	94	307
Stockton Area Streams					
Calaveras River	Stockton	190	332	886	2,677
Westside Stream Group-Delta-Central Sierra					
Marsh-Kellogg Creeks	Brentwood	34	64	173	637
Corral Hollow	Tracy	5	8	20	62
Delta Islands					
Lower San Joaquin River	Antioch	9	15	45	164
Cache Slough and Tributary Streams					
Ulatis Creek	Vacaville	40	78	215	679
Total Delta-Central Subregion		299	533	1,433	4,726

1/ Damages based on July 1965 prices and project conditions, and estimated economic conditions for the year shown.
2/ Figures in column 3 are from column 7, "Total," shown on Table 9.

TABLE 9b

DELTA-CENTRAL SIERRA SUBREGION OF THE CALIFORNIA REGION

Estimated Average Annual Flood Damage and Damage Reduction
for Urban Areas with Significant Flood Problems
- Present and Future Economic Conditions -

Study area/ stream	Damage center	Total damages - 1965 prices ($1,000): 1965 economic & project conditions 1/	1980 economic conditions: W/1965 project conditions 2/	1980: Reduction due to 1966-1980 program: Non-structural measures	1980: Reduction due to 1966-1980 program: Structural measures	1980: Residual damage w/1966-1980 program 3/	2000 economic conditions: W/1966-1980 program	2000: Reduction due to 1981-2000 program: Non-structural measures	2000: Reduction due to 1981-2000 program: Structural measures	2000: Residual damage w/1981-2000 program 4/	2020 economic conditions: W/1981-2000 program	2020: Reduction due to 2001-2020 program: Non-structural measures	2020: Reduction due to 2001-2020 program: Structural measures	2020: Residual damage w/2001-2020 program 5/
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Mokelumne River Basin														
Mokelumne River	Lodi	21	36	10	0	26	84	45	0	39	258	166	0	92
Stockton Area Streams														
Calaveras River	Stockton	190	332	18	279	35	93	46	0	47	153	74	61	18
Westside Stream Group-Delta-Central Sierra														
Marsh Creek	Brentwood	34	64	0	0	64	173	0	149	24	87	0	0	87
Corral Hollow	Tracy	5	8	2	0	6	18	9	0	9	51	38	0	13
Delta Islands														
San Joaquin River	Antioch	9	15	5	0	10	40	24	0	16	135	104	0	31
Cache Slough and Tributary Streams														
Ulatis Creek	Vacaville	40	78	0	0	78	215	0	195	20	63	0	0	63
Total Delta-Central Sierra Subregion		299	533	35	279	219	623	124	344	155	747	382	61	304

1/ Figures shown in column 3 are from column 7 of Table 9 and are also shown in column 3 of Table 9a.
2/ Figures in column 4 are from column 4 of Table 9a.
3/ Column 7 = column 4 - column 5 - column 6.
4/ Column 11 = column 8 - column 9 - column 10.
5/ Column 15 = column 12 - column 13 - column 14.

TABLE 10

DELTA-CENTRAL SIERRA SUBREGION OF THE CALIFORNIA REGION

Estimated Costs of Future Flood Control Program
- 1966 to 1980 -
($1,000)

Study area	Levees & channels: Federal: Installation costs	Levees & channels: Federal: Annual OM&R costs	Levees & channels: Non-Federal: Installation costs	Levees & channels: Non-Federal: Annual OM&R costs	Flood control reservoirs: Federal: Installation costs	Flood control reservoirs: Federal: Annual OM&R costs	Flood control reservoirs: Non-Federal: Installation costs	Flood control reservoirs: Non-Federal: Annual OM&R costs	Non-structural measures: Federal: Installation costs	Non-structural measures: Federal: Annual OM&R costs	Non-structural measures: Non-Federal: Installation costs	Non-structural measures: Non-Federal: Annual OM&R costs
1	2	3	4	5	6	7	8	9	10	11	12	13
Cosumnes River Basin	5,160	0	2,530	58	14,810	23	130	4	110	22	50	10
Mokelumne River Basin	1,300	0	700	8	0	0	0	0	110	58	870	112
Stockton Area Streams	4,650	0	2,350	28	0	0	0	0	30	4	650	12
Westside Stream Group-Delta-Central Sierra	0	0	0	0	490	7	0	0	10	1	90	5
Delta Islands	1,250	0	3,130	16	0	0	0	0	40	17	240	17
Cache Slough and Tributary Streams	0	0	0	0	0	0	0	0	10	8	10	4
Sacramento Deep Water Ship Channel and Project Bypasses in DC	0	0	0	0	0	0	0	0	20	12	30	17
Sacramento River below Sacramento	0	0	0	0	0	0	0	0	40	12	10	4
Total Delta-Central Sierra Subregion	12,360	0	8,710	110	15,300	30	130	4	370	134	1,950	181

AD-A042 196 CALIFORNIA REGION FRAMEWORK STUDY COMMITTEE F/G 8/6
COMPREHENSIVE FRAMEWORK STUDY. CALIFORNIA REGION. APPENDIX IX. --ETC(U)
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TABLE 10a

DELTA-CENTRAL SIERRA SUBREGION OF THE CALIFORNIA REGION

Estimated Costs of Future Flood Control Program
- 1981 to 2000 -
($1,000)

Study area	Levees & channels				Flood control reservoirs				Non-structural measures			
	Federal		Non-Federal		Federal		Non-Federal		Federal		Non-Federal	
	Installation costs	Annual OM&R costs	Installation costs	Annual OM&R costs	Installation costs	Annual OM&R costs	Installation costs	Annual OM&R costs	Installation costs	Annual OM&R costs	Installation costs	Annual OM&R costs
1	2	3	4	5	6	7	8	9	10	11	12	13
Cosumnes River Basin	0	0	0	0	0	0	0	0	90	33	140	24
Mokelumne River Basin	1,220	0	660	15	5,000	30	0	0	110	82	1,000	149
Stockton Area Streams	0	0	0	0	0	0	0	0	50	10	1,630	29
Westside Stream Group-Delta-Central Sierra	1,050	0	70	22	2,570	0	1,220	43	10	2	250	11
Delta Islands	29,250	0	3,500	81	0	0	0	0	50	30	620	35
Cache Slough and Tributary Streams	1,230	0	120	7	100	0	100	2	20	13	60	14
Sacramento Deep Water Ship Channel and Project Bypasses in DC	0	0	0	0	0	0	0	0	10	16	20	22
Sacramento River below Sacramento	8,850	0	4,470	48	0	0	0	0	20	20	10	6
Total Delta-Central Sierra Subregion	41,600	0	8,820	173	7,670	30	1,320	45	360	206	3,730	290

TABLE 10b

DELTA-CENTRAL SIERRA SUBREGION OF THE CALIFORNIA REGION

Estimated Costs of Future Flood Control Program
- 2001 to 2020 -
($1,000)

Study area	Levees & channels				Flood control reservoirs				Non-structural measures			
	Federal		Non-Federal		Federal		Non-Federal		Federal		Non-Federal	
	Installation costs	Annual OM&R costs	Installation costs	Annual OM&R costs	Installation costs	Annual OM&R costs	Installation costs	Annual OM&R costs	Installation costs	Annual OM&R costs	Installation costs	Annual OM&R costs
1	2	3	4	5	6	7	8	9	10	11	12	13
Cosumnes River Basin	4,950	0	2,670	40	3,000	32	0	0	60	47	90	18
Mokelumne River Basin	390	0	80	14	4,200	13	300	1	100	103	2,510	167
Stockton Area Streams	3,190	0	1,720	30	7,030	30	0	0	40	13	1,560	22
Westside Stream Group-Delta-Central Sierra	0	0	0	0	0	0	0	0	10	1	520	9
Delta Islands	11,500	0	13,500	120	0	0	0	0	60	42	1,580	43
Cache Slough and Tributary Streams	0	0	0	0	0	0	0	0	80	17	6,080	43
Sacramento Deep Water Ship Channel and Project Bypasses in DC	0	0	0	0	0	0	0	0	10	20	20	25
Sacramento River below Sacramento	13,300	0	11,700	120	0	0	0	0	20	28	10	8
Total Delta-Central Sierra Subregion	33,330	0	29,670	324	14,230	75	300	1	380	271	12,370	335

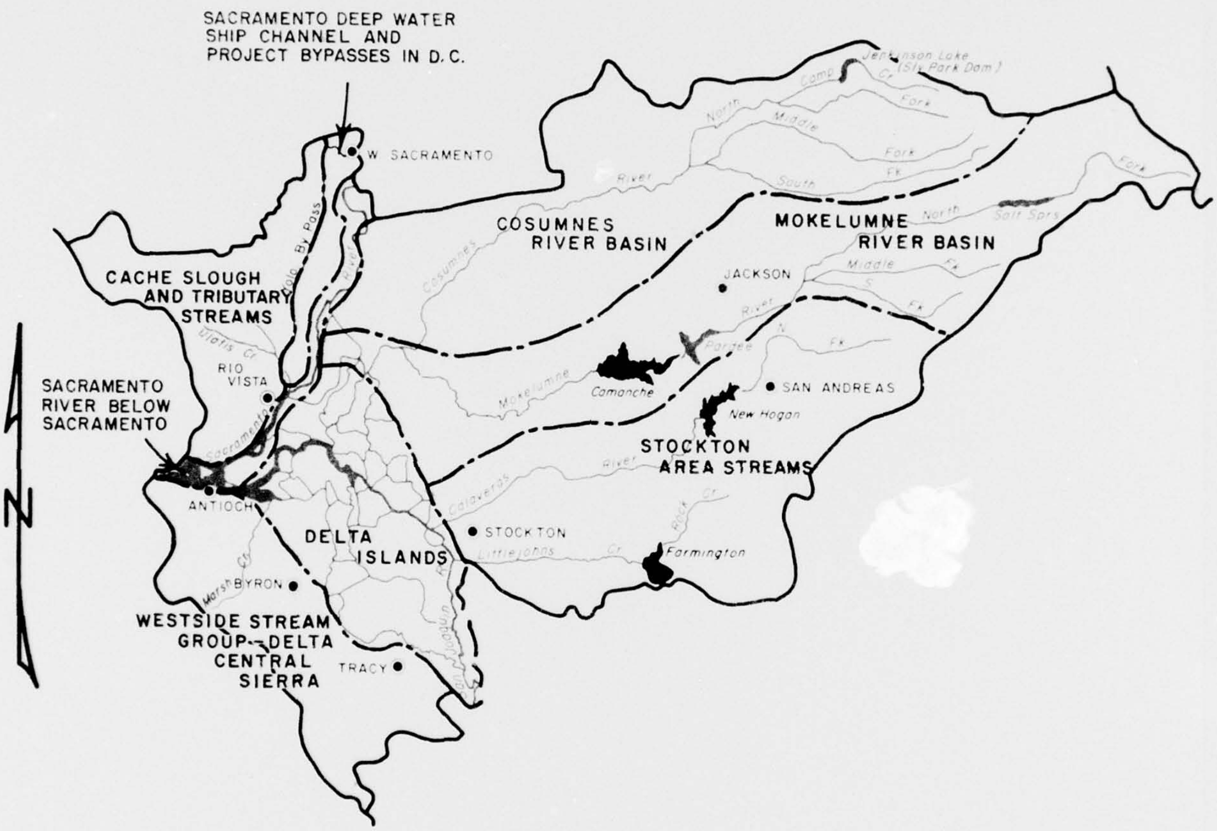
TABLE 11

DELTA-CENTRAL SIERRA SUBREGION OF THE CALIFORNIA REGION

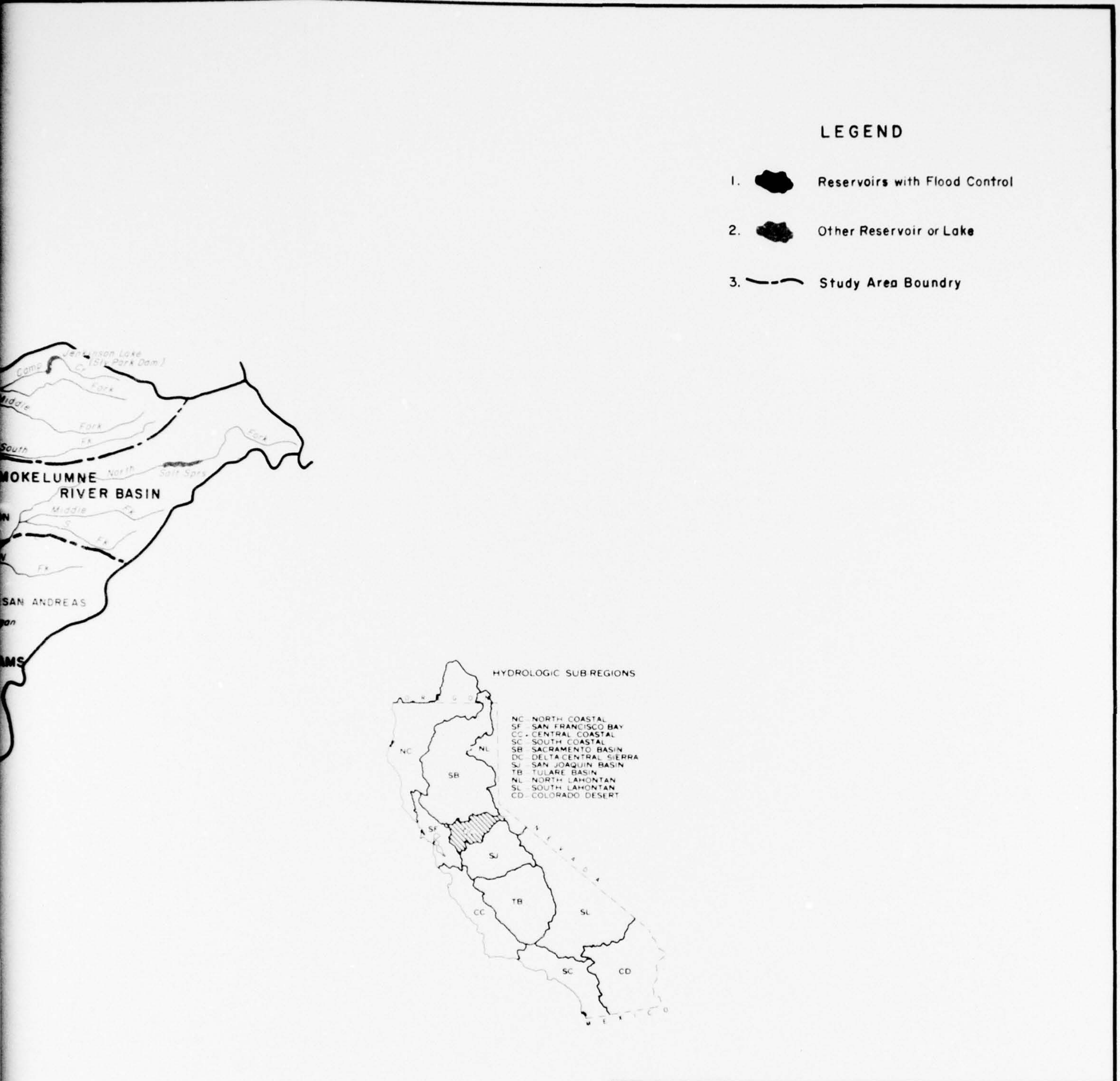
Flow Data at Selected Locations
(Flows in 1,000 cfs)

Study area/ stream	Location	Non-damaging flow 1/	Date	Maximum flood of record: Flow: At time of occurrence	Maximum flood of record: Flow: Existing (1965) project conditions	Maximum flood of record: Flow: Future project conditions 2/: 1980	Maximum flood of record: Flow: Future project conditions 2/: 2000	Maximum flood of record: Flow: Future project conditions 2/: 2020	Flow of standard project flood: Existing (1965) project conditions	Flow of standard project flood: Future project conditions 2/: 1980	Flow of standard project flood: Future project conditions 2/: 2000	Flow of standard project flood: Future project conditions 2/: 2020	Flow of 100-year frequency flood: Existing (1965) project conditions	Flow of 100-year frequency flood: Future project conditions 2/: 1980	Flow of 100-year frequency flood: Future project conditions 2/: 2000	Flow of 100-year frequency flood: Future project conditions 2/: 2020
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Cosumnes River Basin																
Cosumnes River	Michigan Bar	10	23Dec55	42	42	10	10	10	87	60	60	10	62	11	11	10
Mokelumne River Basin																
Mokelumne River	Camanche															
	Inflow		21Nov50	27	27	27	27	27	115	115	115	115	70	70	70	70
	Outflow	5	21Nov50	28	5	5	5	5	30	30	30	30	6	6	6	6
Stockton Area Streams																
Calaveras River	Hogan															
	Inflow		2Apr58	42	42	42	42	42	66	66	66	66	54	54	54	54
	Outflow	6	2Apr58	11	6	10 3/	10	10	36	11	11	11 3/	16	10	10	10 3/
Westside Stream Group-Delta-Central Sierra																
Marsh Creek	At mouth	1	Jan63	4	4	4	4	4	9	3	3	3	7	1	1	1
Delta Islands																
San Joaquin River	Vernalis	30	9Dec50	79	58	31	31	31	160	85	85	85	115	61	61	61
Cache Slough and Tributary Streams																
Cache Slough	Yolo Bypass		Apr58	Unknown					865	785	780	775	500	450	435	430
Sacramento Deep Water Ship Channel & Project Bypasses in DC																
Yolo Bypass	Lisbon Gage	500	20Mar07	428	Unknown											
	Lisbon Gage	500 4/	25Dec64	370	370	330	320	320	850	770	765	760	490	440	425	420
Sacramento River below Sacramento																
Sacramento River	Rio Vista	Varies	26Dec55	9.8 (ft)	9.8	9.7	9.6	9.6	10.3 (ft)	10.1	10.0	10.0	10.1 (ft)	9.9	9.8	9.8

1/ Under 1965 project conditions.
2/ Flows as modified by future projects likely to be in a future flood control program by the years 1980, 2000, and 2020.
3/ Non-damaging flow 10,000 cfs after 1980.
4/ All of the lands within the bypass are owned by the State of California or are covered by flowage easements. However, these fertile lands are intensively farmed and sustain substantial damages from floodflows.



SACRAMENTO DEEP WATER SHIP CHANNEL AND PROJECT BYPASSES IN D.C.
W. SACRAMENTO
Jenkinson Lake (Sly Park Dam)
COSUMNES RIVER BASIN
MOKELUMNE RIVER BASIN
CACHE SLOUGH AND TRIBUTARY STREAMS
JACKSON
RIO VISTA
Camanche
SAN ANDREAS
New Hogan
SACRAMENTO RIVER BELOW SACRAMENTO
STOCKTON AREA STREAMS
ANTIOCH
STOCKTON
DELTA ISLANDS
Farmington
BYRON
WESTSIDE STREAM GROUP-DELTA CENTRAL SIERRA
TRACY
N



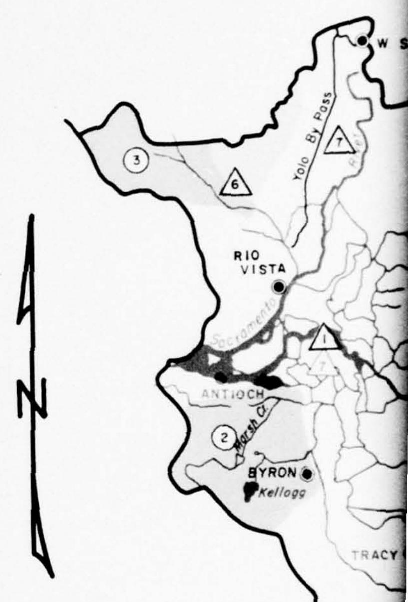
MAP 2

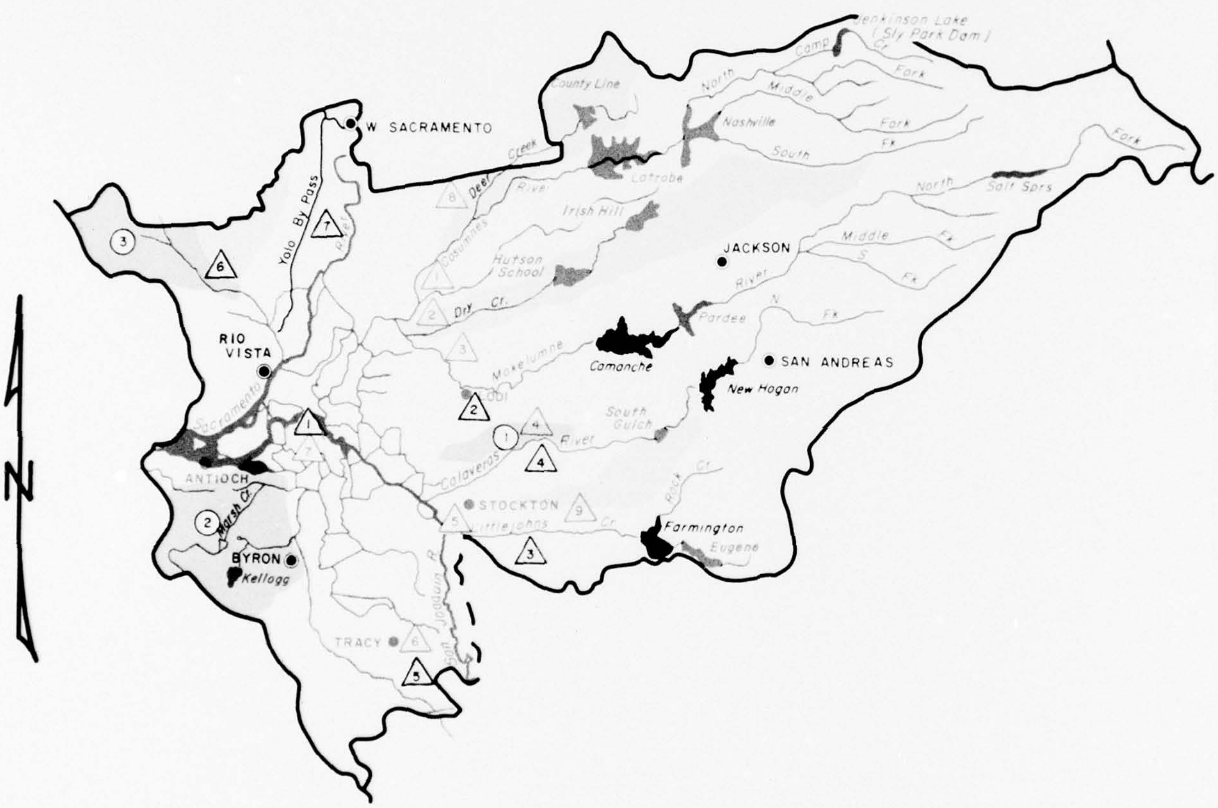
DELTA-CENTRAL SIERRA SUBREGION
CALIFORNIA REGION

FLOOD CONTROL STUDY AREAS

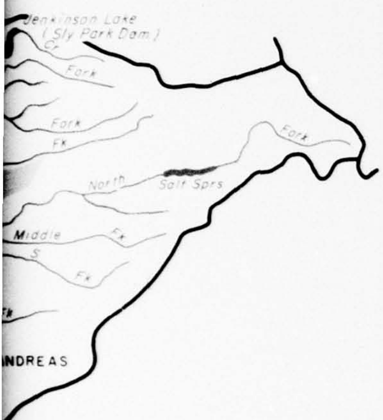
10 0 10 20
SCALE IN MILES


HYDROLOGIC SUB-REGIONS
NC - NORTH COASTAL
SF - SAN FRANCISCO BAY
CC - CENTRAL COASTAL
SC - SOUTH COASTAL
SB - SACRAMENTO BASIN
DC - DELTA-CENTRAL SIERRA
SJ - SAN JOAQUIN BASIN
TB - TULARE BASIN
NL - NORTH LAHONTAN
SL - SOUTH LAHONTAN
CD - COLORADO DESERT
NC
NL
SB
SF
SJ
TB
SL
CC
SC
CD


Yolo By Pass
RIO
VISTA
Sacramento
ANTIOCH
Marsh Cr.
BYRON
Kellogg
TRACY



Jenkinson Lake
(Sly Park Dam)
W. SACRAMENTO
County Line
North
Camp
Cr.
Middle
Fork
Nashville
South
Fk
Latrobe
Deer
Creek
Yolo By Pass
Cosumnes
River
Irish Hill
Hutson School
Dry Cr.
JACKSON
Salt Sprs
Pardee
SAN ANDREAS
RIO VISTA
Sacramento
Mokelumne
Camanche
New Hogan
Lodi
South Gulch
Calaveras
River
ANTIOCH
Marsh Cr.
STOCKTON
Littlejohns
Rock Cr.
Farmington
Eugene
BYRON
Kellogg
TRACY
San Joaquin R.
N



LEGEND

1. Existing Projects (In operation 1965)

Reservoirs with Flood Control
1. Comanche
2. New Hogan
3. Farmington

Other Reservoir or Lake

Levee & Channel Projects
1. Sacramento River & Delta
2. Bear Creek
3. Littlejohns Creek
4. Calaveras River
5. San Joaquin River
6. Cache Slough & Tributaries
7. Sacramento Deep Water Ship Channel & Project Bypasses

Watershed Projects
1. Mosher Creek
2. Marsh-Kellogg
3. Ulatis

2. Potential Future Flood Control Program
A (1966-1980), A_1 (Constructed as of FY 1970), B (1981-2000), C (2001-2080) (See table 6 & 7)

Reservoirs
1. County Line (A)
2. Nashville (A)
3. Latrobe (C)
4. Irish Hill (C)
5. Hutson School (B)
6. South Gulch (C)
7. Eugene (C)
8. Kellogg (A)

Levee & Channel Projects
1. Cosumnes River (A,C)
2. Dry Creek (B)
3. Mokelumne River (A)
4. Calaveras River (A_1) (Mormon Slough)
5. Littlejohns Creek (C)
6. San Joaquin R
7. Delta (C)
8. Deer Creek (A)
9. Duck Creek (A_1)

Watershed Projects

Locations of non-structural floodplain management measures

MAP 3

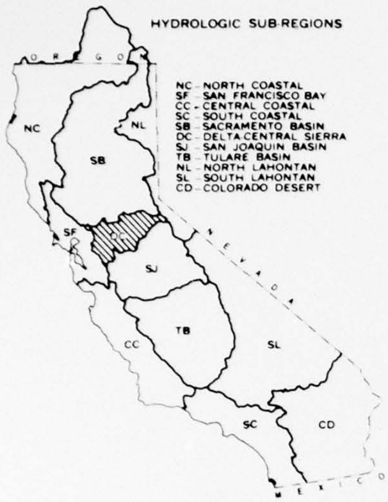
DELTA-CENTRAL SIERRA SUBREGION

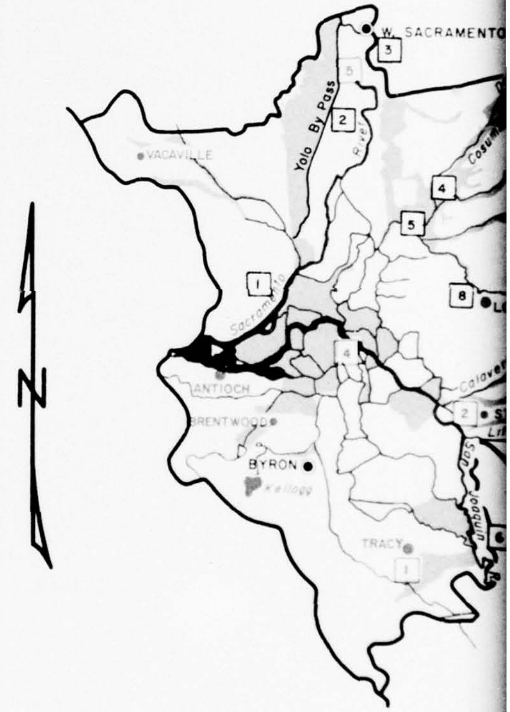
CALIFORNIA REGION

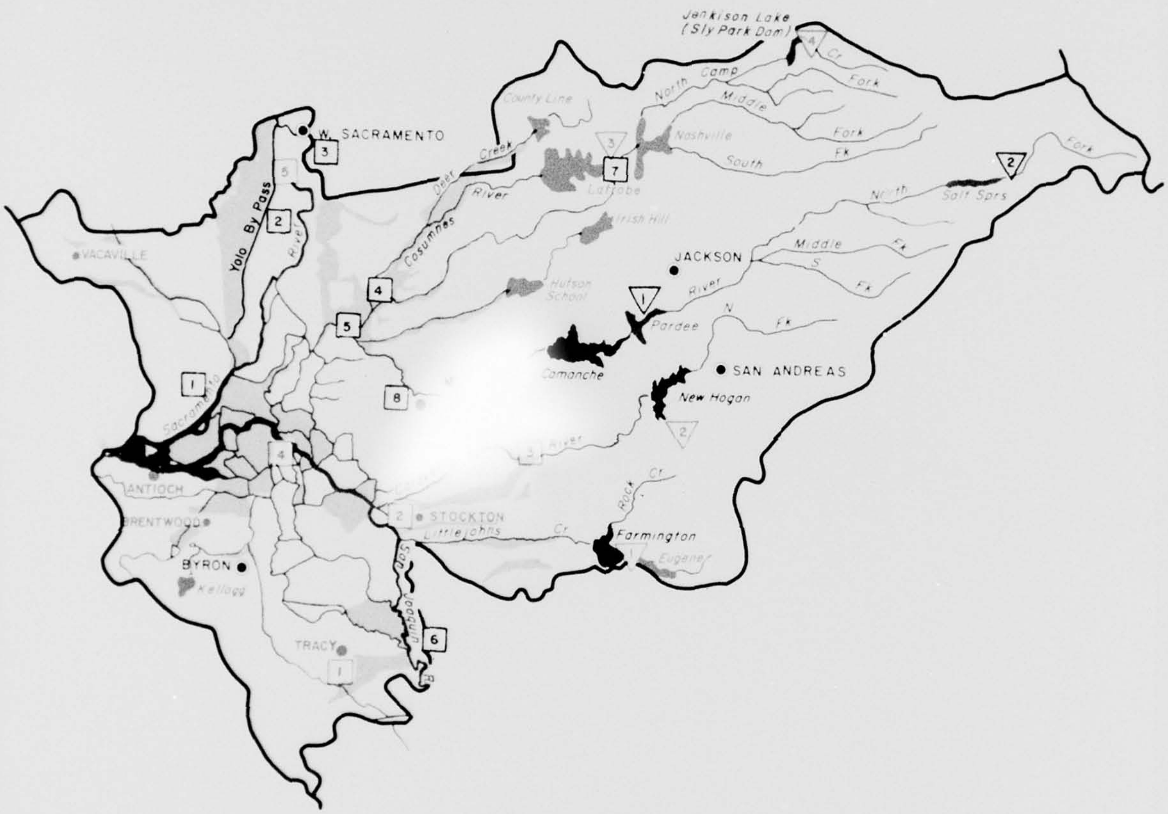
FLOOD CONTROL PLAN

10 0 10 20

SCALE IN MILES


HYDROLOGIC SUB-REGIONS
NC - NORTH COASTAL
SF - SAN FRANCISCO BAY
CC - CENTRAL COASTAL
SC - SOUTH COASTAL
SB - SACRAMENTO BASIN
DC - DELTA-CENTRAL SIERRA
SJ - SAN JOAQUIN BASIN
TB - TULARE BASIN
NL - NORTH LAHONTAN
SL - SOUTH LAHONTAN
CD - COLORADO DESERT
NC
SB
NL
SF
SJ
TB
SL
CC
SC
CD
NEVADA
MEXICO


W. SACRAMENTO
VACAVILLE
Yolo By Pass
River
Sacramento
ANTIOCH
BRENTWOOD
BYRON
Kellogg
TRACY
N



Jenkison Lake
(Sly Park Dam)
W. SACRAMENTO
County Line
North Camp Cr
Middle Fork
Fork
South Fk
Nashville
Deer Creek
Cosumnes River
Latrobe
Irish Hill
Yolo By Pass
River
Sacramento
VACAVILLE
North Fork
Salt Sprs
JACKSON
Middle Fk
S Fk
River
Hutson School
Pardee
N Fk
Camanche
SAN ANDREAS
New Hogan
River
ANTIOCH
BRENTWOOD
BYRON
Kellogg
STOCKTON
Littlejohns Cr
Rock Cr
Farmington
Eugene
San Joaquin
TRACY

1.

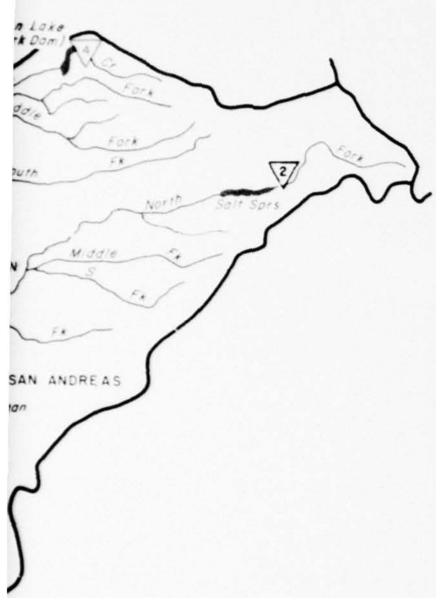
2.

3.

4.

5.

6.



LEGEND

1. Areas Subject to Flooding
2. Major Urban Damage Centers
3. River Forecasting Points

River Stage (Existing)

1. Rio Vista
2. Lisbon
3. I Street
4. Mc Connel
5. Benson's Ferry
6. Lathrop
7. Michigan Bar
8. Woodbridge

River Stage (Future)

1. Tracy Pump
2. Port of Stockton
3. Bellota
4. Burns Cutoff
5. Port of Sacrmento

Reservoir Inflow (Existing)

1. Pardee
2. Salt Springs

Reservoir Inflow (Future)

1. Farmington
2. New Hogan
3. Nashville
4. Sly Park

4. Existing Reservoir with Flood Control
5. Other Resrvoir or Lake
6. Potential Future Reservoir with Flood Control

MAP 4

DELTA-CENTRAL SIERRA SUBREGION

CALIFORNIA REGION

FLOOD DAMAGE AREAS AND RIVER FORECAST SERVICE

10 0 10 20

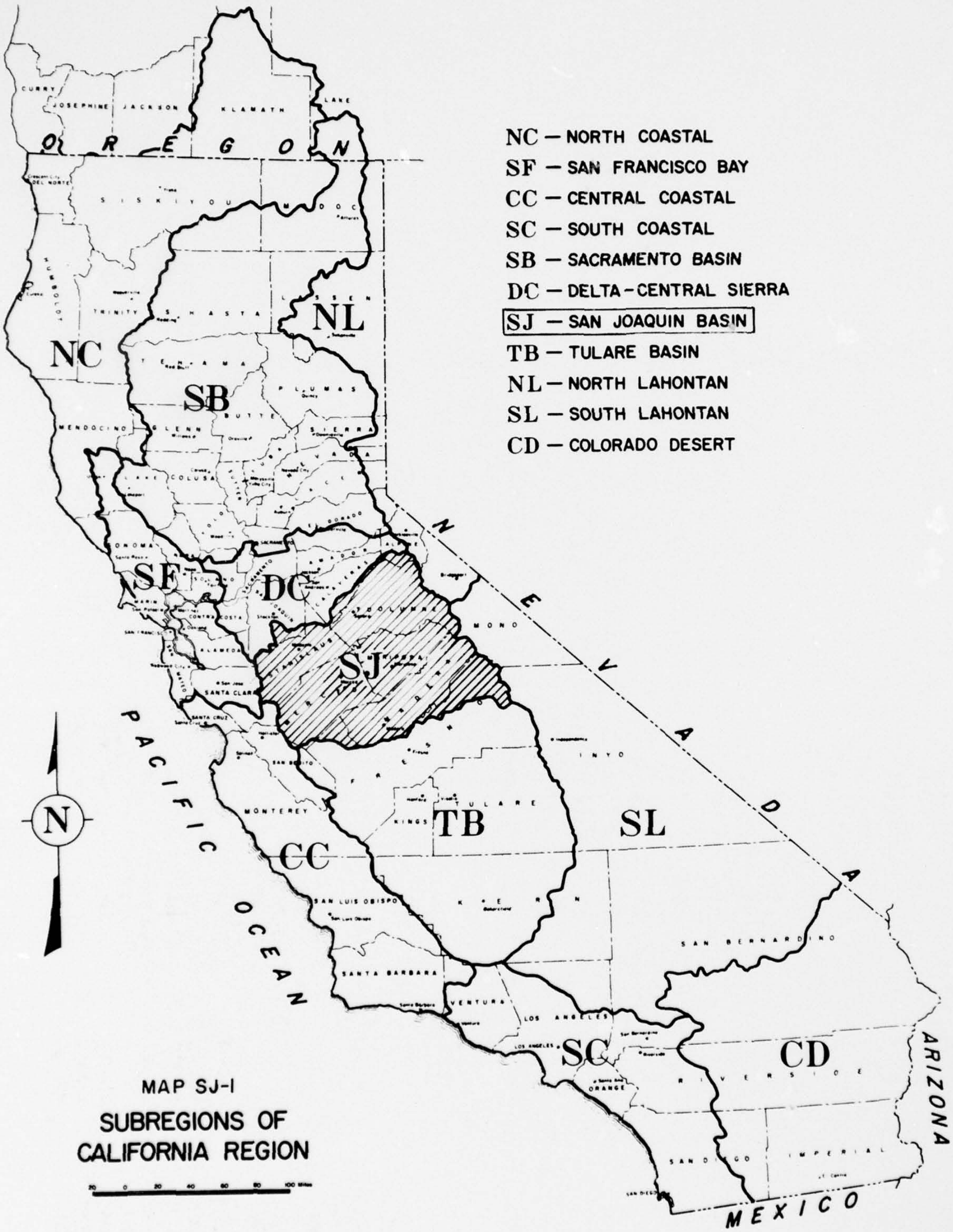
SCALE IN MILES

SAN

JOAQUIN

BASIN

SUBREGION



MAP SJ-1

SUBREGIONS OF CALIFORNIA REGION

SAN JOAQUIN BASIN SUBREGION

General

The San Joaquin Basin Subregion (SJ) is situated in central California. It extends generally from near Stockton on the north to near Fresno on the south, and from the crest of the Sierra Nevada on the east to the coast ranges on the west. (See Map SJ-1.) The subregion is about 110 miles long and 95 miles wide and comprises an area of 11,061 square miles.

The climate of the subregion is characterized by hot, dry summers and mild winters with relatively little precipitation in valley floor areas, and by warm, dry summers and cold winters with heavy rain and snow in the mountainous areas. Average annual precipitation varies with elevation, ranging from about 5 inches in the southern part of the valley floor to over 70 inches in the Sierra Nevada. Temperatures normally range from winter lows below zero in mountain areas to summer highs of about 115 degrees on the valley floor.

The subregion had an estimated population of 385,000 in 1965. Its economy is dominated by highly diversified agricultural activities and related manufacturing and industrial activities. Mining and lumbering are significant in the Sierra Nevada.

Transportation facilities in the subregion are extensive. Highly developed Federal, State, and county road systems afford ready access to all parts of the subregion and to adjoining areas. The area is served by air and rail lines, and the Stockton Deep Water Ship Channel which terminates in the Delta-Central Sierra Subregion.

The San Joaquin River is the principal stream in the San Joaquin Subregion. Originating in glacial lakes in the Sierra Nevada, it flows southwesterly to the vicinity of Mendota, thence northwesterly to its mouth in Suisun Bay. (See Delta-Central Sierra Subregion.) The principal tributaries to San Joaquin River within the region are the Stanislaus, Tuolumne, and Merced Rivers. A number of minor tributaries originating on the eastern slopes of the coastal ranges join San Joaquin River from the west.

Additional information of the subregion can be found in Appendix II, "The Region."

For the investigation of present and future flood problems and the analysis of potential solutions, the subregion has been divided into the following study areas: Stanislaus River Basin, Tuolumne River Basin, Merced River Basin, Merced County Stream Group, Madera County Stream Group, San Joaquin River Basin, and Westside Stream Group-San Joaquin Basin. The principal streams in these areas are shown on Map 2.

History of Flooding

The San Joaquin Subregion is subject to two types of floods: 1) those that occur during the late fall and winter months, primarily as a result of prolonged general rainstorms in the mountain and valley floor areas; and 2) those that occur during the spring and early summer months, primarily as a result of the melting of the winter snowpack in the high areas of the Sierra Nevada. The most significant type is the late fall and winter flood caused by general rainstorms. A description of a few of the major floods of the late 1800's and early 1900's is included in the regional section of the appendix. On a subregional basis, the January 1969 flood is considered to be the most severe although other floods may have caused higher flows on individual streams. The November 1950 flood claimed one life.

During the 1955 flood, antecedent rainfall for the period 21-24 December averaged about 16.5 inches in the upper reaches of the basin and snowmelt added about 1 inch of water to the basin mean rainfall of 10-15 inches. Extensive flooding occurred along the San Joaquin River and all of its major tributaries. Flooding also occurred on the larger westside tributary streams. Over 7,000 people evacuated their homes during the Christmas holiday season and several people died of heart attacks caused by excitement during the flood. Agricultural, public facility, and residential damages comprised nearly 85% of the total flood damage. About 127,000 acres were inundated during the flood and damages exceeded $7 million. Damages for the 1955 and other significant recent floods in the subregion are tabulated on page SJ-3 and are shown in more detail in Tables 1 and 2.

Both rain and snowmelt floods occurred in the San Joaquin Basin Subregion during the 1968-1969 flood season. About 285,000 acres were inundated and flood damages exceeded $19 million. Flood fighting and cleanup costs under various Federal programs were about $800,000. The rain floods resulted from more than 25 inches of rain during January, and substantial but lesser amounts in February. The elevation of this basin reaches 14,000 feet with about 40 percent lying above 8,000 feet. During the rain-flood producing storms a snowpack of unprecedented depth and water content (220-340 percent of normal) was accumulating in the higher elevations. The flood season was climaxed by near record snowmelt floods during the period April through July. Flooding along the Stanislaus and Tuolumne Rivers is shown in Photos SJ-I and SJ-II. Total volume of snowmelt for the San Joaquin Basin Subregion was estimated at 9,000,000 acre-feet which approached the record established in 1906.

Flooding along Stanislaus River, January 1969. (Corps of Engineers Photo.)

PHOTO SJ-I

Tuolumne River in Modesto, January 1969. Floodwaters reached a width of a half mile in the city and damaged more than fifty homes. (Modesto Bee Photo.)

PHOTO SJ-II

Flood (year)	Forest & range resources & facilities	Agricultural & land	Residential & commercial	Industrial & utility	Public facilities	Total
	Flood damages 1/ ($1,000)					
1955	722	3,081	309	432	2,715	7,259
1958	0	3,382	114	6	589	4,091
1962-63	0	279	77	1	168	525
1964-65	238	1,160	9	529	1,326	3,262
1968-69	949	14,347	1,425	298	2,031	19,050

1/ Based on prices and project and economic conditions at time of occurence of flood.

Peak flows of maximum floods of record, 100 year floods, and standard project floods for selected stations in the subregion are shown in Table 11.

Present Status of the Flood Control Improvements

The existing flood control improvements include a variety of measures to reduce flood damage. (See Map 3.) They include flood forecasting, flood control reservoirs, floodwater retardation structures, levees and channels, tributary watershed treatment, and flood plain information studies. Existing measures, which are described in more detail in following paragraphs, provide flood protection to 38% of the areas subject to flooding. With a few exceptions, the degree of protection provided by existing flood control measures varies from 100-year or greater flood protection in urban areas, and from 10- to 50-year flood protection in agricultural areas.

Flood forecasts are prepared by the Federal-State River Forecast Center in Sacramento and distributed by the Sacramento and Fresno River District Offices of the National Weather Service. These forecasts include: 1) inflow to the major reservoirs, 2) routed flow and stage forecasts downstream of the dams, and 3) stage and flow forecasts along the mainstem of the lower San Joaquin River. Forecasting points are shown on Map 4.

Existing major flood control reservoirs in the subregion are operated to provide a maximum of 863,100 acre-feet of flood control storage during the most critical flood situations. These projects are:

Study area	Reservoir	Stream	Flood control capacity (ac.-ft.)	Drainage area (sq. miles)
Tuolumne River Basin	Don Pedro	Tuolumne River	200,000	1,530
	Hetch Hetchy	Tuolumne River	160,000	455
	Cherry Valley	Cherry Creek	80,000	187
	Lake Eleanor	Eleanor Creek		
Merced County Stream Group	Burns	Burns Creek	6,800	74
	Bear	Bear Creek	7,700	72
	Owens	Owens Creek	3,600	26
	Mariposa	Mariposa Creek	15,000	107
San Joaquin River Basin	Millerton Lake (Friant)	San Joaquin River	390,000	1,633

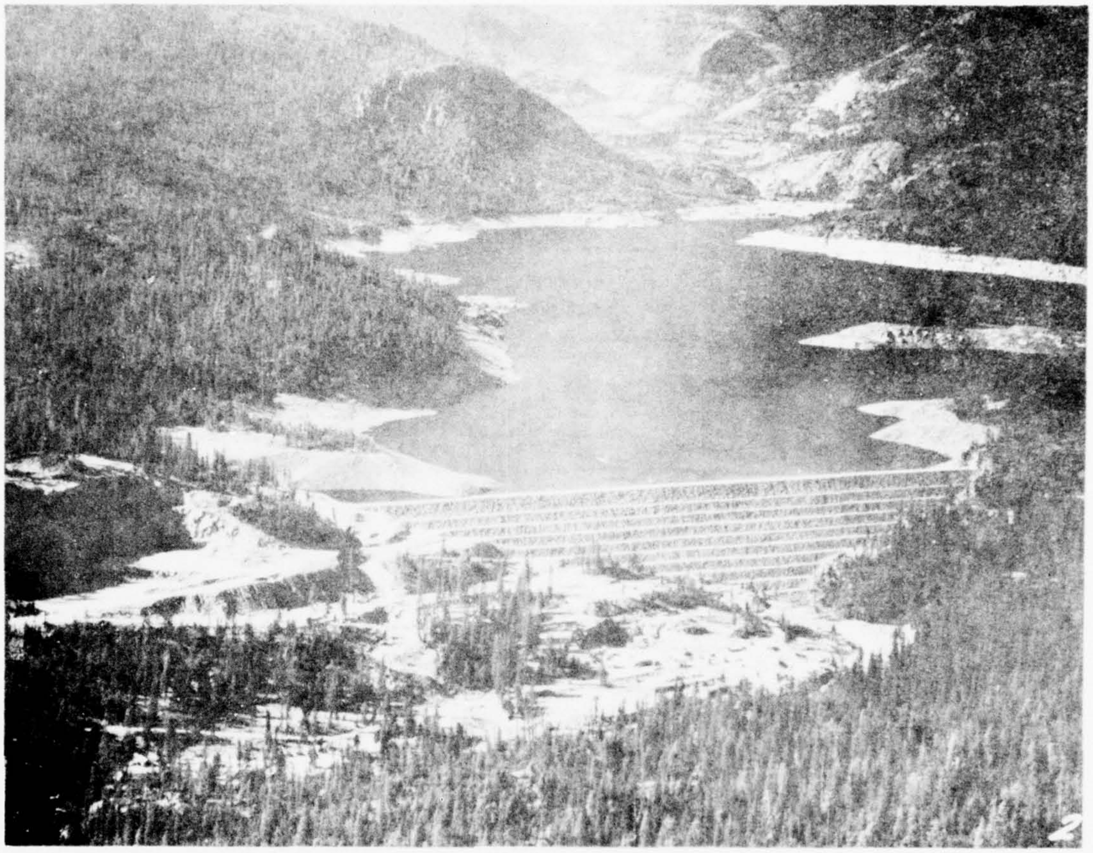
These projects are shown on Map 3. Friant Dam and Cherry Valley Dam are shown in Photos SJ-III and SJ-IV.

Many reservoirs in the subregion, though not having flood control as a designated function, provide incidental, but often significant, flood control benefits. Important reservoirs of this type are:

Reservoir	Stream	Construction agency
Beardsley	Middle Fork Stanislaus	Oakdale South San Joaquin ID
Florence Lake	S. Fork San Joaquin	Southern California Edison Co.
Huntington Lake	Big Creek	Southern California Edison Co.
Mammoth Pool	San Joaquin River	Southern California Edison Co.
Shaver Lake	Stevenson Creek	Southern California Edison Co.
Tulloch	Stanislaus River	Oakdale South San Joaquin ID
Vermilion Valley	Mono Creek	Southern California Edison Co.

Friant Dam and Millerton Lake on San Joaquin River. A portion of the Friant-Kern Canal appears in the right foreground. (Bureau of Reclamation Photo.)

PHOTO SJ-III



Cherry Valley Dam on Cherry Creek, a tributary of Tuolumne River. (Corps of Engineers Photo.)

PHOTO SJ-IV

An extensive system consisting of 277 miles of flood control levees, channels, and bypasses is another element in the overall flood control development of the San Joaquin Subregion. The locations of these features are indicated on Map 3 and data concerning the existing (1965) levee and channel projects are contained in Table 7. In addition to the principal levee and channel systems, local interests have constructed numerous secondary levees and improved channels. These secondary improvements provide a varying degree of protection primarily for agricultural areas. In general, the protection afforded ranges from a once-in-2-year flood to a once-in-25-year flood.

Flood prevention measures installed by private parties in tributary watershed areas are mostly confined to stream channel work and some small levee and channel construction. A few grade stabilization structures are also being installed by these individuals and groups.

The Flood Plain Management Services Program is covered in detail in the Regional Summary of this appendix. Under the program, flood hazard information is being furnished to local agencies for use in evaluating the flood hazard of individual site locations.

Summarizing the flood control improvements the San Joaquin Basin Subregion is afforded a considerable degree of flood protection from the existing flood control measures and other measures that provide incidental flood control benefits. The flood control system existing in 1965 would have prevented $9.6 million in flood damages during the 1955 flood; and prevented $5.3 million in flood damages during the 1964-1965 flood. It is estimated that average annual damages prevented by existing measures exceeds $2.5 million. Additional details are included in Table 2. During the 1968-1969 flood season emergency work was accomplished under Operation Foresight due to the unprecedented snowpack conditions existing prior to the snowmelt flood period. The work consisted largely of channel clearing, and strengthening, raising, extending and reinforcing existing levees on streams that might be affected by runoff from the extremely heavy snowmelt. Most of the work was accomplished on non-Federal improvements. Generally the emergency protective measures were very effective and should be of continuing benefit because the facilities are to be maintained by local interests. The preventive measures taken resulted in benefits exceeding three times the costs expended.

As effective as the existing flood control measures have been to reduce floodflows and resulting flood damage, flood problems still exist in some areas. A major problem in the subregion occurs in the streams below the dams where channel capacities are so restrictive that releases often exceed flood stage damaging agricultural and urban areas. Combined flows from reservoirs from the upper San Joaquin River north to the Stanislaus River can cause considerable flooding along the main stem San Joaquin River below Friant. Some flooding occurs along the Fresno and Chowchilla Rivers in the

vicinity of Madera and Chowchilla. Flooding also occurs along other streams in the area with resulting damages to agricultural and urban properties. (See tabulation below.) The problems are especially serious along the streams of the Merced County and Madera County Stream Groups.

This subregion has erosion and sediment problems associated with flooding. In terms of present and potential damage, streambank erosion and eroding land pose the greatest threat, particularly in the valley areas where intensive agriculture exists. About 2,780 miles of stream channels have erosion problems with 350 miles classed as "serious". Annual losses of land due to bank sloughing amounts to $100,000 and fifty-six acres of land are lost annually, 30 percent of which occurs in urban areas. (See Tables 1, 3, and 4 for the monetary losses associated with land loss and depreciation of productivity on agricultural lands).

In the tributary areas much of the flood problem has not been alleviated. In terms of potential damage, main streambank erosion occurring in the lower elevation tributary watershed areas poses the greatest threat. The land adjoining these channels is used intensively for agriculture and streambank erosion damage occurs as land-loss with associated depreciation of the productive capacity of adjacent lands. Many additional land treatment and flood prevention measures are needed if adequate protection is to be afforded this area.

The aforementioned flood problems result in average annual damages as follows:

Study area	Estimated Average Annual Damages ($1,000) 1/
Stanislaus River Basin	365
Tuolumne River Basin	383
Merced River Basin	450
Merced County Stream Group	618
Madera County Stream Group	882
San Joaquin River Basin	1,091
Westside Stream Group	103
Total San Joaquin Basin Subregion	3,892

1/ Based on 1965 prices, economic conditions and project conditions.

Additional details are contained in Tables 3 and 4 for the subregion as a whole and in Table 9 for urban areas. Major urban centers and areas of the subregion subject to flooding are shown on Map 4.

Future Needs

It is evident from an examination of current (1965) flood problems that additional flood control measures are required. It is estimated that average annual flood damage in the subregion (based on 1965 prices and conditions) is about $3.9 million. The flood problems of the area will increase in the future due to the pressures of population and economic growth and resultant increases in use of flood plains. The population of the San Joaquin River Basin Subregion is projected to increase from 385,000 in 1965 to 487,000 in 1980, 853,000 in 2000 and 1,626,000 in 2020 (base plan projections). Average annual flood damages are expected to increase to about $6.8 million by 1980, to $14.7 million by 2000 and to $36.3 million by 2020 if additional flood control measures are not provided. Estimated damage data for existing and future conditions are contained in Tables 5 and 9a.

Measures Required to Satisfy Future Needs

Improved flood forecasting will be a part of a comprehensive flood control program. The optimum operation of flood control projects can only be assured by a well-coordinated system of forecasting. Forecast procedural development and improvement should continue apace with the development of new projects. But improved forecasts are dependent upon improving the network for collecting hydrologic data. This will require expansion of the present data network including a considerable amount of additional telemetry for this subregion which at the present time has the least instrumentation of any major runoff area in the State of California. The required improvements to the flood forecasting system are estimated to cost $330,000 for the 1966-1980 period, $260,000 for the 1981-2000 period, and $210,000 for the 2001-2020 period.

Floodwater storage in reservoirs and detention structures will be an important element of the future flood control program. An additional 1,775,000 acre-feet of flood control capacity are required in the subregion to satisfy future needs. This total is derived from the following tabulation:

Study area/ time frame in which needed	Reservoir	Stream	Flood control capacity (ac.-ft.)	Drainage area (sq. miles)
Stanislaus River Basin				
1966-1980 1/	New Melones	Stanislaus River	450,000	900
Tuolumne River Basin				
1966-1980 1/ 2/	New Don Pedro	Tuolumne River	340,000	1,542

Study area/ time frame in which needed	Reservoir	Stream	Flood control capacity (ac.-ft.)	Drainage area (sq. miles)
Merced River Basin				
1966-1980 1/	New Exchequer	Merced River	400,000	1,037
1966-1980	Detention Structures (2)	(Various)	1,000	12
1981-2000	Montgomery	Merced River	45,000	68
1981-2000	Bagby	Merced River	350,000	912
2001-2020	Detention Structures (2)	(Various)	4,000	22
Merced County Streams				
1966-1980	Merced Group	Merced Stream Group	37,000	385
1981-2000	Detention Structures (2)	(Various)	14,000	96
Madera County Streams				
1966-1980	Buchanan	Chowchilla River	45,000	235
1966-1980	Hidden	Fresno River	65,000	237
1966-1980	Detention Structures (9)	(Various)	6,000	93
1981-2000	Detention Structures (3)	(Various)	2,000	39
2001-2020	Detention Structure	No Name	2,000	16
Westside Stream Group-San Joaquin Basin				
1966-1980 3/	Los Banos	Los Banos Creek	14,000	156
Total 2/			1,775,000	

1/ Under construction or funded for construction as of FY 71.
2/ Pending construction of New Don Pedro Reservoir, 440,000 acre-feet of flood control capacity are provided in upstream reservoirs and is deducted from the future capacity total. See Table 6.
3/ Completed in FY 69.

The reservoirs listed above are shown on Map 3 and additional information on flood control storage is contained in Table 6. Estimated costs for additional flood control capacity are $84.6 million for the 1966-1980 period, $38.3 million for the 1981-2000 period and $2.5 million for the 2001-2020 period.

In addition to these reservoirs, levee and channel work is desirable in the following areas of the San Joaquin Subregion.

Study area	Levees (Bank Miles)	Channels (Miles)
Tuolumne River Basin		
2001-2020	10	5
Merced River Basin		
1966-1980	0	17
1981-2000	2	0
2001-2020	0	6
Merced County Stream Group		
1966-1980	36	52
1981-2000	5	9
Madera County Stream Group		
1966-1980	16	11
1981-2000	0	3
2001-2020	15	7
San Joaquin River Basin		
1966-1980 1/	19	0
1981-2000	40	5
2001-2020	15	10
Total	158	125

1/ Under construction or funded for construction as of FY 70.

The approximate location of levees and channel work is indicated on Map 3 and additional details are included in Table 7. The estimated costs for required levee and channel work are $3.9 million for the 1966-1980 period, $8.8 million for the 1981-2000 period, and $6.1 million for the 2001-2020 period.

Structural measures will be complemented by non-structural land treatment measures for necessary soil and water conservation. In this subregion, the land treatment measures will include most of the practice discussed in the Regional Summary of this appendix. Map 3 shows potential watershed projects. Estimated costs and acres of watershed land treatment are tabulated on page SJ-10.

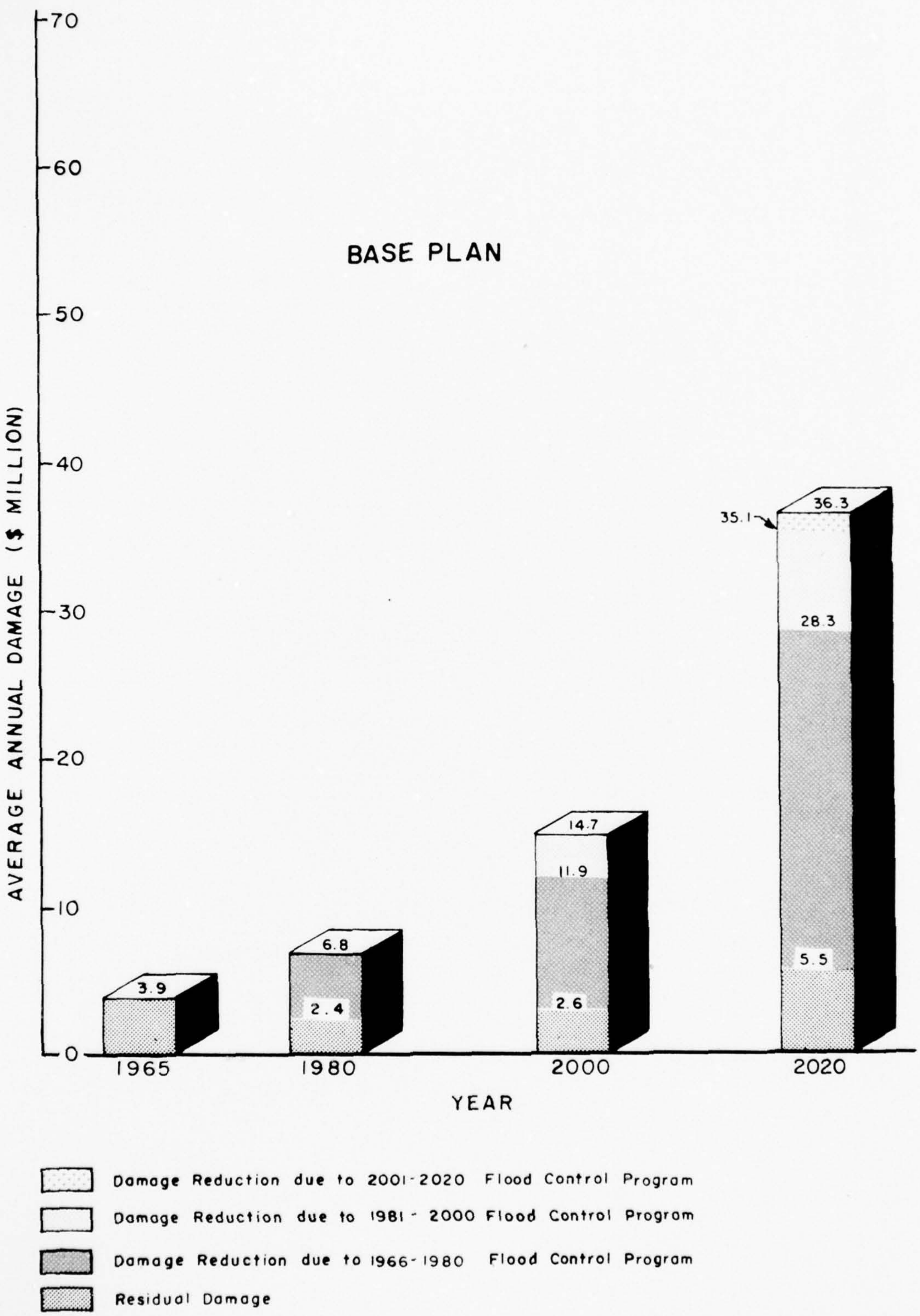
Land Treatment	1966-1980	1981-2000	2001-2020
Thousand acres	15	38	20
Thousand dollars	800	1,900	1,100

Non-structural flood plain management measures will become an increasingly important part of community flood control planning in the San Joaquin River Basin during the 1966-1980 time frame, in the Merced Stream Group and Tuolumne River Basin after 1981 and in the Madera County Stream Group after 2001. Table 9b shows damages reduced by such measures for urban centers. Non-structural flood plain management measures to accomplish these reductions will consist primarily of zoning and flood proofing. Communities in this subregion with populations in excess of 2,500 with known significant flood problems include Los Banos, Modesto, Newman, Madera, Merced, Paradise, Patterson, Sonora, Chowchilla, and Firebaugh. Many communities with expanding populations are expected to have flood problems in the future, and will be studied as their needs are made known. Flood plain information reports for the communities named above are scheduled for completion by 1980. Comprehensive flood damage prevention planning and implementation of non-structural flood plain management measures would follow in each flood problem area identified. Flood plain management measures along approximately 55 stream miles could be implemented for urban areas including the above listed communities. Map 3 shows the areas for which non-structural flood plain management measures are proposed.

Costs for future non-structural flood plain management measures are estimated at $2.8 million for the 1966-1980 period, $6.2 million for the 1981-2000 period, and $14.0 million for the 2001-2020 period.

Potential to Satisfy Future Needs

The flood control program presented herein would reduce the projected average annual damages $4.4 million by 1980, $12.1 million by 2000, and $30.8 million by 2020 at an estimated installation cost of $92.4 million for the period 1966-1980, $55.4 million for 1981-2000, and $23.9 million for 2001-2020. Estimated annual OM&R costs for the 1966-1980, 1981-2000 and 2001-2020 portions of the flood control program are $0.76 million, $0.69 million and $0.63 million (See Tables 10, 10a and 10b). The effect of the potential flood control program on future damages is shown in Table 8 and graphically on Figure SJ-1, and its effect on floodflows is shown in Table 11.



CALIFORNIA REGION
COMPREHENSIVE FRAMEWORK STUDY

PROJECTED AVERAGE ANNUAL FLOOD DAMAGES
(1965 PRICES AND PROJECT CONDITIONS—DATA FROM TABLES 5 & 8)

APPENDIX IX FIGURE SJ-1

TABLE 1

SAN JOAQUIN BASIN SUBREGION OF THE CALIFORNIA REGION

Historical Flood Data

Study area	Flood	Location/ flow (cfs)	Area inundated (1,000 acres)	Flood damages 1/ - ($1,000) Forest & range resources	Forest & range facilities	Crop & pasture	Other agricultural	Land	Residential & commercial	Industrial & utility	Public facilities	Total
1	2	3	4	5	6	7	8	9	10	11	12	13
Stanislaus River Basin	Nov-Dec 50	Melones Inflow 90,000 (Outflow 45,000)	15.0	4	35	318	221	344	58	20	176	1,176
	Dec55	Melones Inflow 102,000 (Outflow 62,800)	15.1	9	70	315	219	342	85	94	893	2,027
	Dec64	Melones Inflow 48,700 (Outflow 39,000)	11.4	12	24	352	244	381	9	9	633	1,664
Tuolumne River Basin	Nov-Dec 50	Don Pedro Inflow 90,000 (Outflow 64,500)	8.1	2	58	124	98	74	300	15	39	710
	Dec55	Don Pedro Inflow 100,000 (Outflow 42,800)	7.1	3	106	85	112	143	10	0	289	748
Merced River Basin	Nov-Dec 50	Exchequer Inflow 88,000 (Outflow 38,000)	19.8	0	509	130	130	112	37	164	1,353	2,435
	Dec55	Exchequer Inflow 100,000 (Outflow 10,700)	3.9	3	247	7	7	6	0	24	542	836
	Dec-Jan 65	Exchequer Inflow 35,000 (Outflow 17,000)	1.9	5	35	25	6	30	0	520	321	942
Merced County Stream Group	Dec55	Mariposa Inflow 15,000 (Outflow 5,800)	15.3	0	0	163	24	46	91	24	174	522
Madera County Stream Group	Dec55	Fresno River at Hidden site 17,500	57.6	0	43	301	178	21	49	11	341	944
San Joaquin River Basin	Dec55	Friant Inflow 96,000 (Outflow 6,000)	19.6	1	240	234	307	390	5	285	164	1,626
	Jan-Apr 58	Friant Inflow 20,700 (Outflow 7,100)	84.9	1	60	505	667	848	11	0	294	2,386
Westside Stream Group-San Joaquin Basin	Dec55	Los Banos site 11,900	8.7	0	0	41	32	24	33	0	159	289

1/ Data based on prices and project and economic conditions at time of occurrence of flood.

TABLE 2

SAN JOAQUIN BASIN SUBREGION OF THE CALIFORNIA REGION

Flood Damage 1/

Study area	Flood	Location/ flow (cfs)	Total damages - ($1,000) At time of flood 2/ Actual damage	Damage without flood control projects	Damage prevented by flood control projects 4/	1965 economic conditions & prices 3/ Damage with 1965 project conditions	Damage without flood control projects	Damage prevented by 1965 projects 5/
1	2	3	4	5	6	7	8	9
Stanislaus River Basin	Dec55	Melones Inflow 102,000 (Outflow 62,800)	2,027	2,027	0	3,235	3,235	0
Tuolumne River Basin	Dec55	Don Pedro Inflow 100,000 (Outflow 42,800)	748	1,834	1,086	1,126	2,755	1,629
Merced River Basin	Dec55	Exchequer Inflow 100,000 (Outflow 10,700)	836	836	0	1,401	1,401	0
Merced County Stream Group	Dec55	Mariposa Inflow 15,000 (Outflow 5,800)	522	5,222	4,700	890	8,955	8,065
Madera County Stream Group	Dec55	Chowchilla R. at Buchanan site 30,000 and Fresno R. at Hidden site 17,500	944	944	0	1,651	1,651	0
San Joaquin River Basin	Dec55	Friant Inflow 96,000 (Outflow 6,000)	1,626	15,980	14,354	2,198	25,921	23,723
Westside Stream Group-San Joaquin Basin	Dec55	Los Banos site 11,400	289	289	0	379	685	306

1/ Maximum flood for which data are available.
2/ Data based on prices and project and economic conditions at time of occurrence of flood.
3/ Data based on recurrence of original flood.
4/ Column 6 = column 5 - column 4.
5/ Column 9 = column 8 - column 7.

TABLE 3

SAN JOAQUIN BASIN SUBREGION OF THE CALIFORNIA REGION

Estimated Flood Damage for
the 100-Year Frequency Flood 1/
for Selected Streams

Study area/ stream	Area inundated (1,000 acres)	Flood damage 2/ - ($1,000) Forest & range resources	Forest & range facilities	Crop & pasture	Other agricultural	Land	Residential & commercial	Industrial & utilities	Public facilities	Total
1	2	3	4	5	6	7	8	9	10	11
Stanislaus River Basin — Stanislaus River	39.5	9	70	901	625	998	243	354	2,627	5,827
Tuolumne River Basin — Tuolumne River	13.6	6	183	434	572	755	176	0	2,625	4,751
Merced River Basin — Merced River	43.1	9	511	1,641	1,525	1,018	395	927	2,156	8,182
Merced County Stream Group — Bear Creek	97.7	0	0	1,916	521	66	9,245	131	64	11,943
Madera County Stream Group — Fresno-Chowchilla Rivers	114.5	0	75	4,143	1,498	184	3,195	594	4,298	13,987
San Joaquin River Basin — San Joaquin River	170.0	2	300	2,595	3,400	4,336	1,391	1,681	2,075	15,780
Westside Stream Group-San Joaquin Basin — Los Banos Creek	33.3	0	0	636	138	71	464	37	999	2,345

1/ See Table 11 for magnitude of 100-year flood at selected stations.
2/ Based on July 1965 prices, economic conditions, and project conditions.

Base Plan

TABLE 4

SAN JOAQUIN BASIN SUBREGION OF THE CALIFORNIA REGION

Estimated Average Annual Flood Damage

Study area (principal stream)	Flood damage 1/ - ($1,000)								
	Forest & range resources	Forest & range facilities	Crop & pasture	Other agricultural	Land	Residential & commercial	Industrial & utilities	Public facilities	Study area totals
1	2	3	4	5	6	7	8	9	10
Stanislaus River Basin (Stanislaus River)	2	14	54	38	63	13	24	157	365
Tuolumne River Basin (Tuolumne River)	1	37	42	56	76	9	0	162	383
Merced River Basin (Merced River)	2	38	75	131	46	20	37	101	450
Merced County Stream Group (Bear Creek)	0	0	240	32	12	326	4	4	618
Madera County Stream Group (Fresno-Chowchilla River)	0	15	309	126	24	112	22	274	882
San Joaquin River Basin (San Joaquin River)	0	60	159	222	272	113	123	142	1,091
Westside Stream Group - San Joaquin Basin (Los Banos Creek)	0	0	30	6	3	17	5	42	103
Total San Joaquin Subregion	5	164	909	611	496	610	215	882	3,892

1/ Damages based on July 1965 prices, economic conditions, and project conditions.

Base Plan

TABLE 5

SAN JOAQUIN BASIN SUBREGION OF THE CALIFORNIA REGION

Summary of Estimated Average Annual Flood Damage for Present
and Future Conditions of Economic Development
with Existing Flood Control Measures

Study area (principal stream)	Average annual flood damages 1/ - ($1,000)			
	1965 economic conditions 2/	1980 economic conditions	2000 economic conditions	2020 economic conditions
1	2	3	4	5
Stanislaus River Basin (Stanislaus River)	365	590	1,232	3,027
Tuolumne River Basin (Tuolumne River)	383	604	1,212	2,926
Merced River Basin (Merced River)	450	737	1,293	3,362
Merced County Stream Group (Bear Creek)	618	1,190	2,655	6,562
Madera County Stream Group (Chowchilla & Fresno Rivers)	882	1,637	3,952	10,769
San Joaquin River Basin (San Joaquin River)	1,091	1,911	3,922	8,646
Westside Stream Group-San Joaquin Basin (Los Banos)	103	178	391	1,018
Total San Joaquin Basin Subregion	3,892	6,847	14,657	36,310

1/ Damages based on July 1965 prices and project conditions, and estimated economic conditions for the year shown.
2/ Figures in column 2 are from column 10 of Table 4.

TABLE 6

SAN JOAQUIN BASIN SUBREGION OF THE CALIFORNIA REGION

Summary of Flood Control Capacity for Existing
and Future Reservoirs

Study area	Flood control capacity 1/ - (1,000 ac-ft)				
	Existing projects (1965)	Projects 1966-1980 2/	Projects 1981-2000 2/	Projects 2001-2020 2/	Total projects as of 2020
1	2	3	4	5	6
Stanislaus River Basin	0	450	0	0	450
Tuolumne River Basin	440	340	0	0	340 3/
Merced River Basin	0	401	395	4	800
Merced County Stream Group	33	37	14	0	84
Madera County Stream Group	0	116	2	2	120
San Joaquin River Basin	390	0	0	0	390
Westside Stream Group - San Joaquin Basin	0	14	0	0	14
Total San Joaquin Subregion	863	1,358	411	6	2,198

1/ Maximum flood control capacity. Does not include surcharge storage.
2/ Includes only reservoirs controlling the 100-year flood, or better, at the damsite immediately above urban areas and reservoirs controlling at least the 10-year flood at the damsite where only rural areas are to be protected.
3/ Upstream storage in Tuolumne River Reservoirs transferred to New Don Pedro upon construction.

TABLE 7

SAN JOAQUIN BASIN SUBREGION OF THE CALIFORNIA REGION

Summary of Levee and Channel Flood Protection Projects
- Existing and Future -

Study area	Levee and channel projects									
	Existing projects (1965)		Projects 1966-1980 1/		Projects 1981-2000 1/		Projects 2001-2020 1/		Total projects as of 2020	
	Levees (miles)	Channels (miles)	Levees (miles)	Channels (miles)	Levees (miles)	Channels (miles)	Levees (miles)	Channels (miles)	Levees (miles)	Channels (miles)
1	2	3	4	5	6	7	8	9	10	11
Stanislaus River Basin	4	0	0	0	0	0	0	0	4	0
Tuolumne River Basin	0	0	0	0	0	0	10	5	10	5
Merced River Basin	0	0	0	17	2	0	0	6	2	23
Merced County Stream Group	32	0	36	52	5	9	0	0	73	61
Madera County Stream Group	0	0	16	11	0	3	15	7	31	21
San Joaquin River Basin	241	0	19	0	40	5	15	10	315	15
Total San Joaquin Subregion	277	0	71	80	47	17	40	28	435	125

1/ Includes only projects giving 100-year flood protection, or better, to urban areas and at least 10-year flood protection to agricultural areas.

TABLE 8

SAN JOAQUIN BASIN SUBREGION OF THE CALIFORNIA REGION

Estimated Average Annual Flood Damage and Damage Reduction
- Present and Future Economic Conditions -

Study area (principal stream)	Total damages - 1965 prices ($1,000)									
	1965 economic & project conditions 1/	1980 economic conditions			2000 economic conditions			2020 economic conditions		
		W/1965 project conditions 2/	Reduction in damages due to 1966-1980 flood control program 3/	Residual damage W/ 1966-1980 program 4/	W/1966-1980 program	Reduction in damages due to 1981-2000 flood control program 3/	Residual damage W/ 1981-2000 program 5/	W/1981-2000 program	Reduction in damages due to 2001-2020 flood control program 3/	Residual damage W/ 2001-2020 program 6/
1	2	3	4	5	6	7	8	9	10	11
Stanislaus River Basin (Stanislaus River)	365	590	509	81	151	0	151	335	0	335
Tuolumne River Basin (Tuolumne River)	383	604	424	180	394	109	285	782	295	487
Merced River Basin (Merced River)	450	737	383	354	623	198	425	1,070	5	1,065
Merced County Stream Group (Bear Creek)	618	1,190	952	238	531	303	228	747	290	457
Madera County Stream Group (Chowchilla & Fresno Rivers)	882	1,637	1,555	82	440	98	342	1,126	294	832
San Joaquin River Basin (San Joaquin River)	1,091	1,911	472	1,439	3,086	2,056	1,030	2,292	150	2,142
Westside Stream Group San Joaquin Basin (Los Banos)	103	178	114	64	172	42	130	338	144	194
Total San Joaquin Subregion	3,892	6,847	4,409	2,438	5,397	2,806	2,591	6,690	1,178	5,512

1/ Figures shown in column 2 are from column 10 of Table 4 and are also shown in column 2 of Table 5.
2/ Figures in column 3 are from column 3 of Table 5.
3/ Includes structural and non-structural measures.
4/ Column 5 = column 3 - column 4.
5/ Column 8 = column 6 - column 7.
6/ Column 11 = column 9 - column 10.

TABLE 9

SAN JOAQUIN BASIN SUBREGION OF THE CALIFORNIA REGION

Estimated Average Annual Flood Damage for Urban
Areas with Significant Flood Problems

Study area/ stream	Damage center	Average annual flood damages ($1,000) 1/				
		Residential	Commercial	Industrial & utilities	Public facilities	Total
1	2	3	4	5	6	7
Tuolumne River Basin						
Tuolumne River	Paradise	2	0	0	15	17
Tuolumne River	Modesto	7	0	0	80	87
Woods Creek	Sonora	2	3	2	5	12
Merced County Stream Group						
Bear Creek	Merced	102	10	2	1	115
Madera County Stream Group						
Chowchilla River	Chowchilla	15	37	11	18	81
Fresno River	Madera	39	20	10	29	98
San Joaquin River Basin						
San Joaquin River	Firebaugh	31	26	22	40	119
Westside Stream Group-San Joaquin Basin						
Salado Creek	Patterson	1	3	0	2	6
Los Banos Creek	Los Banos	6	5	2	3	16
Orestimba Creek	Newman	0	0	4	8	12
Total San Joaquin Subregion		205	104	53	201	563

1/ Damages are based on July 1965 prices, economic conditions, and project conditions.

TABLE 9a

SAN JOAQUIN BASIN SUBREGION OF THE CALIFORNIA REGION

Summary of Estimated Average Annual Flood Damage for Urban Areas with Significant Flood Problems
- Present and Future Conditions of Economic Development
with Existing Flood Control Measures -

Study area/ stream	Damage center	Average annual flood damages 1/ - ($1,000) 1965 economic conditions 2/	1980 economic conditions	2000 economic conditions	2020 economic conditions
1	2	3	4	5	6
Tuolumne River Basin					
Tuolumne River	Paradise	17	28	76	226
Tuolumne River	Modesto	87	142	386	1,148
Woods Creek	Sonora	12	24	68	220
Merced County Stream Group					
Bear Creek	Merced	115	254	698	1,964
Madera County Stream Group					
Chowchilla River	Chowchilla	81	193	650	2,085
Fresno River	Madera	98	232	783	2,026
San Joaquin River Basin					
San Joaquin River	Firebaugh	119	274	899	2,070
Westside Stream Group-San Joaquin Basin					
Salado Creek	Patterson	6	11	31	91
Los Banos Creek	Los Banos	16	33	91	252
Orestimba Creek	Newman	12	21	53	149
Total San Joaquin Subregion		563	1,212	3,735	10,231

1/ Damages are based on July 1965 prices and project conditions, and estimated economic conditions for the year shown.
2/ Figures in column 3 are from column 7, "Total," shown on Table 9.

TABLE 9b

SAN JOAQUIN BASIN SUBREGION OF THE CALIFORNIA REGION

Estimated Average Annual Flood Damage and Damage Reduction
for Urban Areas with Significant Flood Problems
- Present and Future Economic Conditions -

Study area/ stream	Damage center	Total damages - 1965 prices ($1,000): 1965 economic & project conditions 1/	1980 economic conditions: W/1965 project conditions 2/	1980: Reduction due to 1966-1980 program: Non-structural measures	1980: Reduction due to 1966-1980 program: Structural measures	1980: Residual damage w/1966-1980 program 3/	2000 economic conditions: W/1966-1980 program	2000: Reduction due to 1981-2000 program: Non-structural measures	2000: Reduction due to 1981-2000 program: Structural measures	2000: Residual damage w/1981-2000 program 4/	2020 economic conditions: W/1981-2000 program	2020: Reduction due to 2001-2020 program: Non-structural measures	2020: Reduction due to 2001-2020 program: Structural measures	2020: Residual damage w/2001-2020 program 5/
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Tuolumne River Basin														
Tuolumne River	Paradise	17	28	0	19	9	24	12	0	12	36	11	11	14
Tuolumne River	Modesto	87	142	0	96	46	125	63	0	62	184	51	58	75
Woods Creek	Sonora	12	24	10	0	14	58	34	0	24	176	134	0	42
Merced County Stream Group														
Bear Creek	Merced	115	254	0	106	148	407	207	0	200	562	290	0	272
Madera County Stream Group														
Chowchilla	Chowchilla	81	193	0	188	5	17	0	0	17	54	0	0	54
Fresno	Madera	98	232	0	192	40	135	76	0	59	275	173	0	102
San Joaquin River Basin														
San Joaquin River	Firebaugh	119	274	124	0	150	775	0	667	108	248	0	0	248
Westside Stream Group-San Joaquin Basin														
Los Banos Creek	Los Banos	16	33	0	32	1	3	0	0	3	8	0	0	8
Orestimba Creek	Newman	12	21	[illegible]	0	14	46	26	0	20	116	90	0	26
Salido Creek	Patterson	6	11	4	0	7	27	16	0	11	71	54	0	17
Total San Joaquin Subregion		563	1,212	145	633	434	1,617	434	667	516	1,730	803	69	858

1/ Figures shown in column 3 are from column 7 of Table 9 and are also shown in column 3 of Table 9a.
2/ Figures in column 4 are from column 4 of Table 9a.
3/ Column 7 = column 4 - column 5 - column 6.
4/ Column 11 = column 8 - column 9 - column 10.
5/ Column 15 = column 12 - column 13 - column 14.

TABLE 10

SAN JOAQUIN BASIN SUBREGION OF THE CALIFORNIA REGION

Estimated Costs of Future Flood Control Program
- 1966 to 1980
($1,000)

Study area	Levees & channels				Flood control reservoirs				Non-structural measures			
	Federal		Non-Federal		Federal		Non-Federal		Federal		Non-Federal	
	Installation costs	Annual OM&R costs	Installation costs	Annual OM&R costs	Installation costs	Annual OM&R costs	Installation costs	Annual OM&R costs	Installation costs	Annual OM&R costs	Installation costs	Annual OM&R costs
1	2	3	4	5	6	7	8	9	10	11	12	13
Stanislaus River Basin	0	0	0	0	20,400	68	0	0	80	16	40	11
Tuolumne River Basin	0	0	0	0	15,100	0	0	38	100	20	290	26
Merced River Basin	330	0	250	5	8,880	0	200	38	50	7	70	10
Merced County Stream Group	0 1/	0 1/	0 1/	0 1/	17,060	130	2,020	62	50	17	110	29
Madera County Stream Group	0 2/	0 2/	0 2/	0 2/	16,970	95	1,380	29	70	17	70	16
San Joaquin River Basin	950	0	2,380	12	0	0	0	0	200	41	2,470	55
Westside Stream Group-San Joaquin Basin	0	0	0	0	2,620	2	0	0	50	6	290	12
Total San Joaquin Subregion	1,280	0	2,630	17	81,030	295	3,600	167	600	124	3,340	159

1/ Costs of channel work included with associated reservoir costs.
2/ Costs of channel work included with associated reservoir costs.

TABLE 10a

SAN JOAQUIN BASIN SUBREGION OF THE CALIFORNIA REGION

Estimated Costs of Future Flood Control Program
- 1981 to 2000 -
($1,000)

Study area	Levees & channels				Flood control reservoirs				Non-structural measures			
	Federal		Non-Federal		Federal		Non-Federal		Federal		Non-Federal	
	Installation costs	Annual OM&R costs	Installation costs	Annual OM&R costs	Installation costs	Annual OM&R costs	Installation costs	Annual OM&R costs	Installation costs	Annual OM&R costs	Installation costs	Annual OM&R costs
1	2	3	4	5	6	7	8	9	10	11	12	13
Stanislaus River Basin	0	0	0	0	0	0	0	0	100	31	100	23
Tuolumne River Basin	0	0	0	0	0	0	0	0	190	42	1,810	61
Merced River Basin	170	0	30	1	35,200	71	0	0	110	17	160	24
Merced County Stream Group	900	0	20	20	1,680	0	700	9	170	29	2,930	57
Madera County Stream Group	120	0	40	3	410	0	300	2	130	34	1,190	39
San Joaquin River Basin	2,330	0	5,180	25	0	0	0	0	240	79	270	82
Westside Stream Group-San Joaquin Basin	0	0	0	0	0	0	0	0	110	15	820	27
Total San Joaquin Subregion	3,520	0	5,270	49	37,290	71	1,000	11	1,050	247	7,280	313

TABLE 10b

SAN JOAQUIN BASIN SUBREGION OF THE CALIFORNIA REGION

Estimated Costs of Future Flood Control Program
- 2001 to 2020 -
($1,000)

Study area	Levees & channels				Flood control reservoirs				Non-structural measures			
	Federal		Non-Federal		Federal		Non-Federal		Federal		Non-Federal	
	Installation costs	Annual OM&R costs	Installation costs	Annual OM&R costs	Installation costs	Annual OM&R costs	Installation costs	Annual OM&R costs	Installation costs	Annual OM&R costs	Installation costs	Annual OM&R costs
1	2	3	4	5	6	7	8	9	10	11	12	13
Stanislaus River Basin	0	0	0	0	0	0	0	0	60	37	60	22
Tuolumne River Basin	980	0	530	9	0	0	0	0	140	42	3,270	63
Merced River Basin	190	0	50	17	2,050	0	60	12	60	11	100	14
Merced County Stream Group	0	0	0	0	340	0	80	1	90	34	4,420	69
Madera County Stream Group	460	0	250	4	0	0	0	0	100	32	2,350	39
San Joaquin River Basin	1,400	0	2,230	10	0	0	0	0	160	82	2,550	91
Westside Stream Group-San Joaquin Basin	0	0	0	0	0	0	0	0	100	9	1,860	35
Total San Joaquin Subregion	3,030	0	3,060	40	2,390	0	140	13	710	247	14,610	333

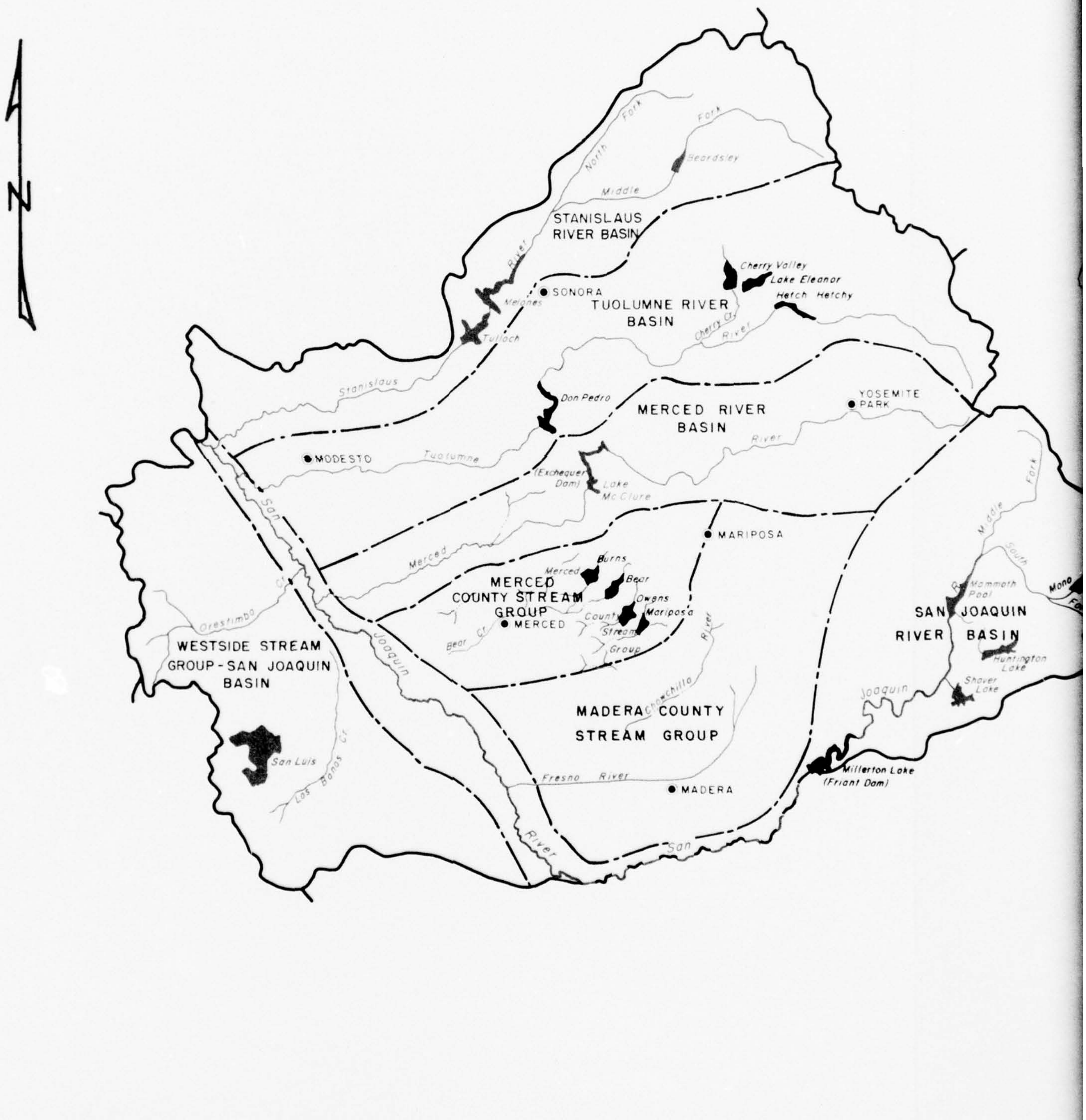
TABLE 11

SAN JOAQUIN BASIN SUBREGION OF THE CALIFORNIA REGION

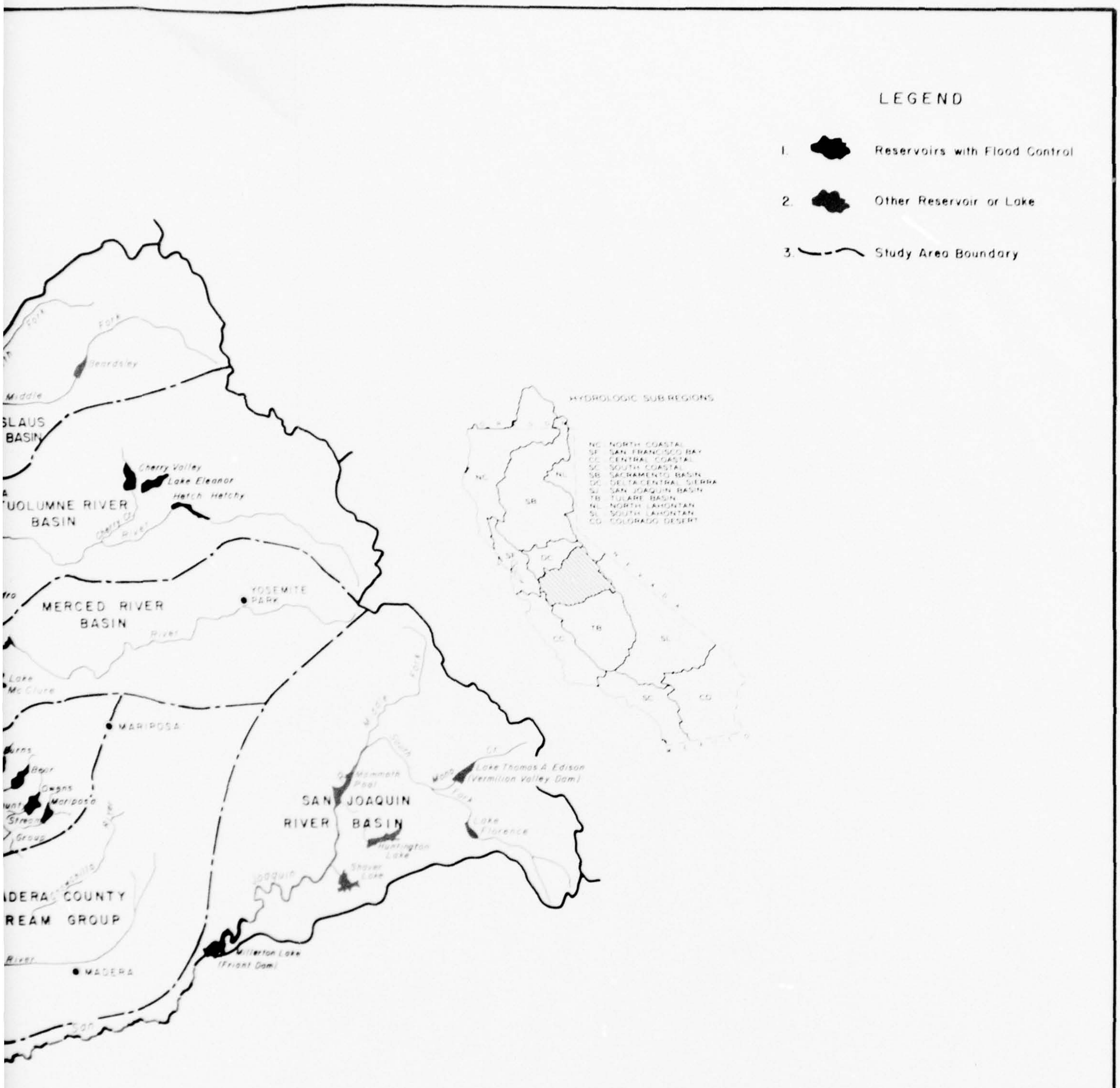
Flow Data at Selected Locations
(Flows in 1,000 cfs)

Study area/ stream	Location	Non-damaging flow 1/	Date	Maximum flood of record Flow: At time of occurrence	Maximum flood of record Flow: Existing (1965) project conditions	Maximum flood of record Flow: Future project conditions 2/ 1980	2000	2020	Flow of standard project flood: Existing (1965) project conditions	Flow of standard project flood: Future project conditions 2/ 1980	2000	2020	Flow of 100-year frequency flood: Existing (1965) project conditions	Flow of 100-year frequency flood: Future project conditions 2/ 1980	2000	2020
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Stanislaus River Basin																
Stanislaus River	Melones															
	Inflow		23Dec55	102	90	90	90	90	142	142	142	142	111	111	111	111
	Outflow	8	23Dec55	63	47	8	8	8	142	8	8	8	111	8	8	8
Tuolumne River Basin																
Tuolumne River	Don Pedro															
	Inflow		22Dec55	100	100	100	100	100	230	230	230	230	135	135	135	135
	Outflow	9	22Dec55	42	42	9	9	9	230	165	165	165	135	30	30	30
Merced River Basin																
Merced River	Exchequer															
	Inflow		23Dec55	100	100	100	100	100	167	167	167	167	138	138	138	138
	Outflow	6	23Dec55	10	10	5	5	5	142	120	6	6	102	60	6	6
Merced County Stream Group																
Mariposa Creek	Mariposa															
	Inflow		23Dec55	15	11	11	11	11	20	20	20	20	17	17	17	17
	Outflow	2	23Dec55	6	6	2	2	2	14	6	6	6	9	3	3	3
Madera County Stream Group																
Chowchilla River	Buchanan															
	Inflow		23Dec55	30	30	30	30	30	59	59	59	59	39	39	39	39
	Outflow	5	23Dec55	30	30	7	7	7	59	36	36	36	39	7	7	7
Fresno River	Hidden															
	Inflow		23Dec55	18	18	18	18	18	49	49	49	49	30	30	30	30
	Outflow	5	23Dec55	18	18	5	5	5	49	17	17	17	30	5	5	5
San Joaquin River Basin																
San Joaquin River	Friant															
	Inflow		23Dec55	96	96	96	96	96	161	161	161	161	108	108	108	108
	Outflow	8	23Dec55	6	6	6	6	6	8	8	8	8	8	8	8	8
Westside Stream Group-San Joaquin Basin																
Los Banos Creek	Los Banos															
	Inflow		23Dec55	11	11	11	11	11	26	26	26	26	20	20	20	20
	Outflow	1	23Dec55	11	3/	3/	3/	3/	4	4	4	4	2	2	2	2

1/ Under 1965 project conditions.
2/ Flows as modified by future projects likely to be in a future flood control program by the years 1980, 2000, and 2020.
3/ Less than 1,000 cfs.



N
STANISLAUS RIVER BASIN
TUOLUMNE RIVER BASIN
MERCED RIVER BASIN
MERCED COUNTY STREAM GROUP
WESTSIDE STREAM GROUP-SAN JOAQUIN BASIN
MADERA COUNTY STREAM GROUP
SAN JOAQUIN RIVER BASIN
North Fork
Middle Fork
Beardsley
River
Melones
Tulloch
SONORA
Cherry Valley
Lake Eleanor
Hetch Hetchy
Cherry Cr.
River
Stanislaus
Don Pedro
YOSEMITE PARK
River
MODESTO
Tuolumne
(Exchequer Dam)
Lake McClure
MARIPOSA
Merced
Burns
Merced
Bear
Owens
Mariposa
County Stream Group
MERCED
Bear Cr.
River
Orestimba Cr.
San
Joaquin
River
San Luis
Los Banos Cr.
Chowchilla
Fresno River
MADERA
Millerton Lake
(Friant Dam)
Joaquin
San
Middle Fork
South
Mammoth Pool
Mono
Huntington Lake
Shaver Lake



MAP 2
SAN JOAQUIN BASIN SUBREGION
CALIFORNIA REGION
FLOOD CONTROL STUDY AREAS

N
HYDROLOGIC SUB-REGIONS
NC - NORTH COASTAL
SF - SAN FRANCISCO BAY
CC - CENTRAL COASTAL
SC - SOUTH COASTAL
SB - SACRAMENTO BASIN
DC - DELTA-CENTRAL SIERRA
SJ - SAN JOAQUIN BASIN
TB - TULARE BASIN
NL - NORTH LAHONTAN
SL - SOUTH LAHONTAN
CD - COLORADO DESERT
NC
NL
SB
SF
DC
TB
CC
SL
SC
CD
North
River
New Melones
SONORA
Melones
Tulloch
River
New Don Pedro
Don Pedro
Stanislaus
MODESTO-PARADISE
Tuolumne
Lake McClure (Exchequer Dam) (New Exchequer)
Montgomery
PATTERSON
San
Merced
Castle
Haystack Mtn.
Merced County Stream
Orestimba Cr.
NEWMAN
Joaquin
MERCED
Bear Cr
San Luis
Los Banos Cr.
Los Banos
Fresno
River
FIREBAUGH
River

LEGEND

1. Existing Projects (in operation 1965)

Reservoirs with Flood Control

1. Cherry Valley	6. Hetch Hetchy
2. Burns	7. Don Pedro
3. Bear	8. Lake Eleanor
4. Owens	9. Millerton Lake (Friant Dam)
5. Mariposa	

Other Reservoir or Lake

Levee & Channel Projects

1. San Joaquin River (Non Federal)
2. Stanislaus River
3. Merced Stream Group

2. Potential Future Flood Control Program

A (1966-1980), A_1 (Constructed or Funded for Construction as of F.Y. 1970), B (1981-2000), C (2001-2020) (See Table 6 & 7)

Reservoirs with Flood Control

1. New Melones (A_1)	9. Burns (A)
2. New Don Pedro (A_1)	10. Bear (A)
3. New Exchequer (A_1)	11. Owens (A)
4. Bagby (B)	12. Mariposa (A)
5. Montgomery (B)	13. Marguerite (A)
6. Castle (A)	14. Buchanan (A_1)
7. Los Banos (A_1)	15. Hidden (A_1)
8. Haystack Mtn. (A)	

Levee & Channel Projects

1. San Joaquin River (Federal) (A_1, B, C)
2. Cottonwood Creek (C)
3. Chowchilla River (A)
4. Fresno River (A)
5. Tuolumne River (C)
6. Merced Stream Group (A)

Watershed Projects

Locations of non-structural floodplain management measures

MAP 3

SAN JOAQUIN BASIN SUBREGION

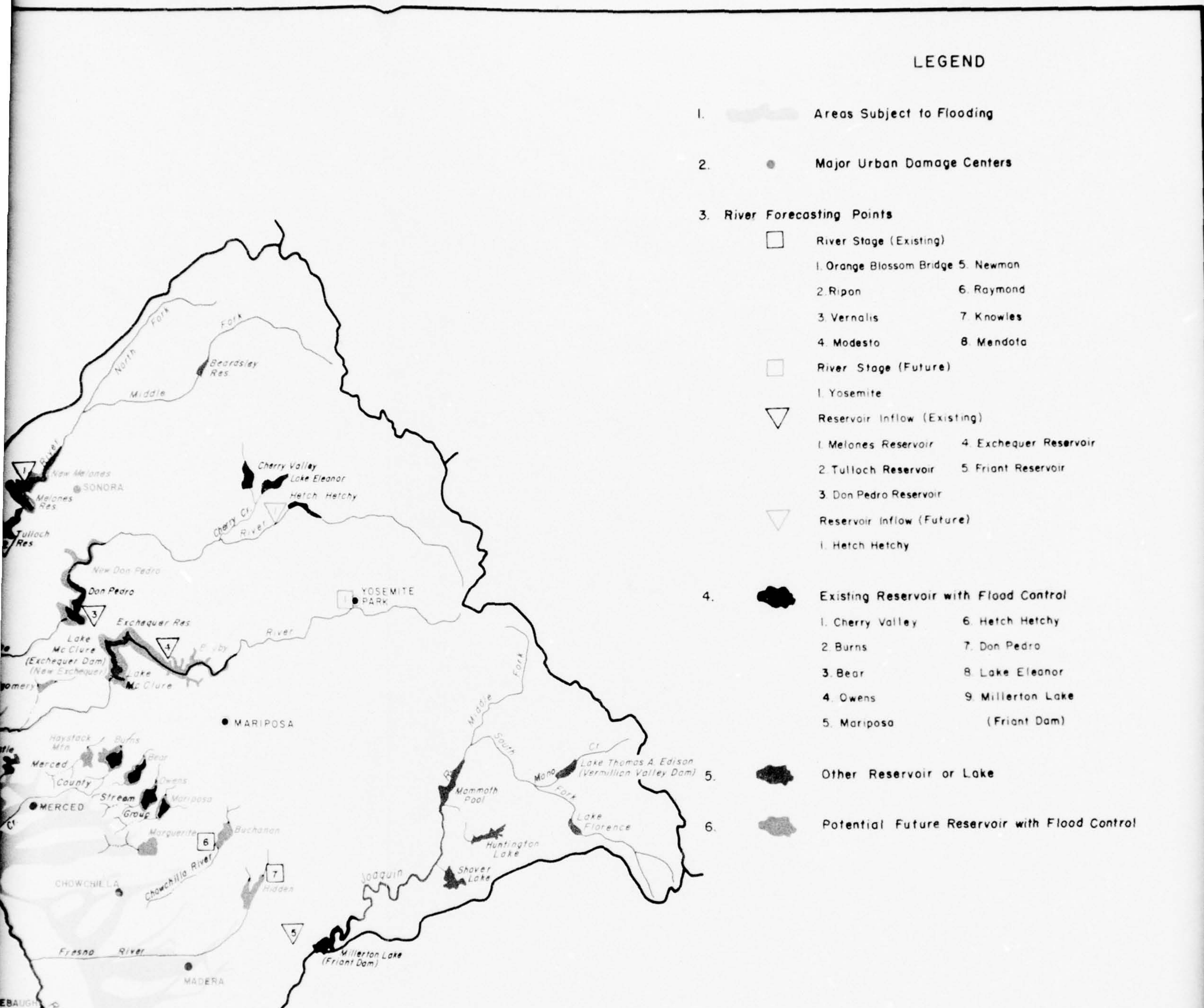
CALIFORNIA REGION

FLOOD CONTROL PLAN

10 0 10 20

SCALE IN MILES


N
HYDROLOGIC SUB REGIONS
NC - NORTH COASTAL
SF - SAN FRANCISCO BAY
CC - CENTRAL COASTAL
SC - SOUTH COASTAL
SB - SACRAMENTO BASIN
DC - DELTA CENTRAL SIERRA
SJ - SAN JOAQUIN BASIN
TB - TULARE BASIN
NL - NORTH LAHONTAN
SL - SOUTH LAHONTAN
CD - COLORADO DESERT
NC
SB
NL
SF
DC
TB
CC
SL
SC
CD
Tulloch Res.
Stanislaus
MODESTO-PARADISE
Tuolumne
Montgomery
San
PATTERSON
Merced
Castle
Orestimba Cr.
NEWMAN
Joaquin
Bear Cr.
Los Banos Cr.
LOS BANOS
San Luis
Los Banos
FIREBAUGH



MAP 4

SAN JOAQUIN BASIN SUBREGION

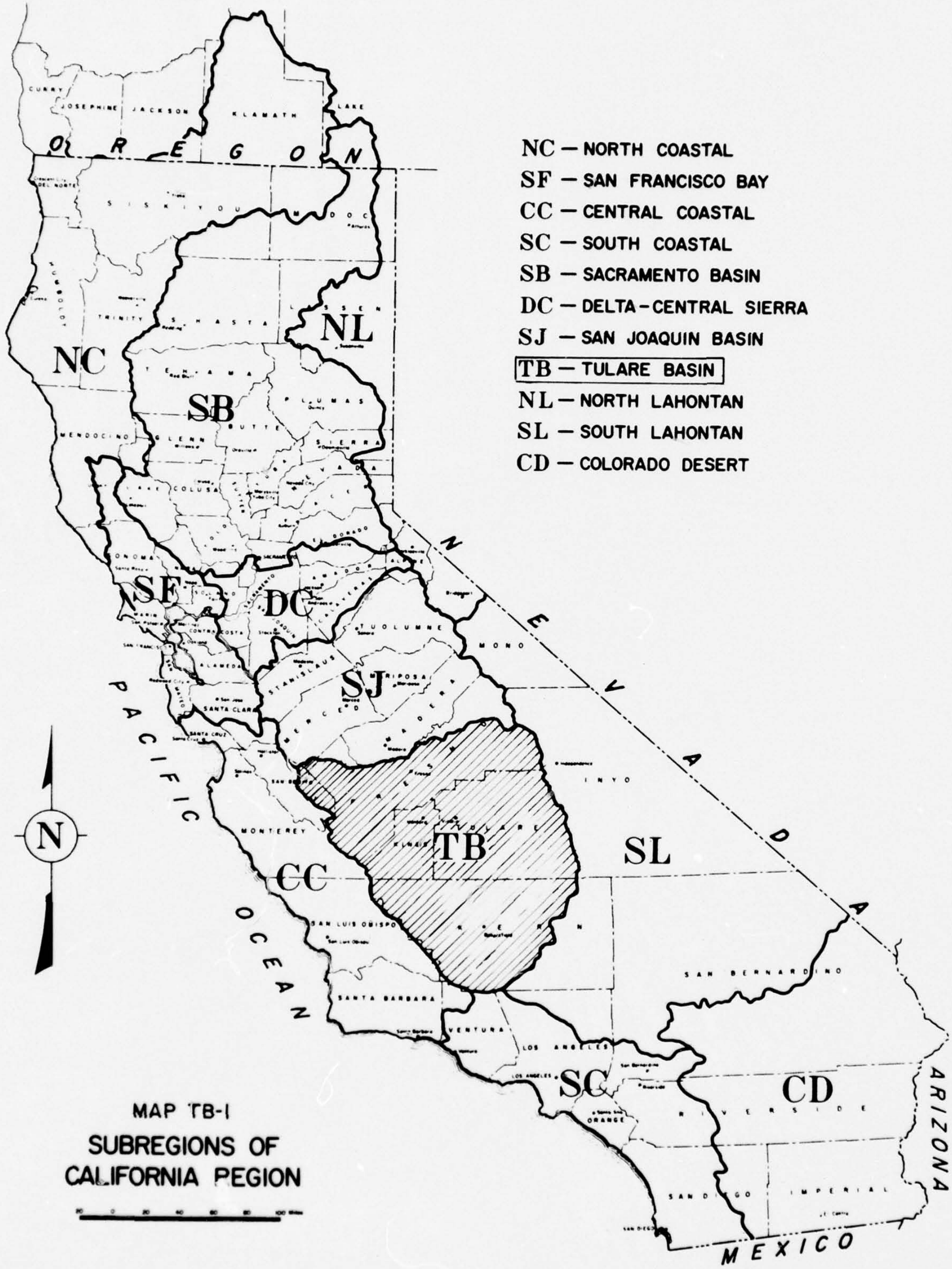
CALIFORNIA REGION

FLOOD DAMAGE AREAS AND RIVER FORECAST SERVICE

TULARE

BASIN

SUBREGION



MAP TB-1
SUBREGIONS OF CALIFORNIA PEGION

TULARE BASIN SUBREGION

General

The Tulare Basin Subregion (TB) is situated in south central California. It extends generally from Fresno on the north to the Tehachapi Mountains on the south, and from the crest of the Sierra Nevada on the east to the coastal ranges on the west. (See Map TB-1.) The subregion is about 160 miles long and 150 miles wide and comprises an area of 17,391 square miles.

The climate of the subregion is characterized by hot, dry summers and mild winters with relatively little precipitation in valley floor areas, and by warm dry summers and cold winters with heavy rain and snow in the mountainous areas. Average annual precipitation varies with elevation, ranging from a minimum of about 5 inches on the valley floor to over 50 inches in the Sierra Nevada. Temperatures normally range from winter lows well below zero in mountain areas to summer highs of over 115 degrees on the valley floor.

The subregion had an estimated population of 906,000 in 1965. Its economy is based primarily on agriculture, the petroleum and other diversified industries, mineral production, and tourism. Lumbering and the production of electric transformers, electronic and component parts for missiles and satellites, Portland cement, tile, brick, and pharmaceutical products are also significant economic activities.

Transportation facilities in the subregion are extensive. Highly developed Federal, State, and county road systems afford ready access to all parts of the subregion and to adjoining areas. The area is served by air and rail lines.

The basin, whose only outlet to the sea is a distributary of Kings River, is separated from San Joaquin Basin to the north by a low ridge formed by the coalesced alluvial cones of the Kings and upper San Joaquin Rivers.

The major streams draining the subregion are Kings, Kaweah, Tule, and Kern Rivers. These streams all rise in the Sierra Nevada and, with the exception of Kings River, terminate in the ancient beds of Tulare or Buena Vista Lakes. Kings River, flowing along the alluvial ridge between the Tulare and San Joaquin Basins, divides to form Kings River South, which flows into Tulare Lake, and Kings River North, which flows into San Joaquin River. A number of minor streams and stream groups drain the areas between the major stream basins along Sierra Nevada, and other stream groups drain the eastern slopes of the coastal ranges.

Additional information of the subregion can be found in Appendix II, "The Region."

For the investigation of present and future flood problems and the analysis of potential solutions, the subregion has been divided into the following study areas: Fresno County Stream Group, Kings River Basin, Kaweah River Basin, Tule River Basin, Poso Creek Stream Group, Kern River Basin, Caliente Creek Basin, Streams Tributary to Buena Vista Lake, Westside Stream Group-Tulare Basin, and Tulare Lake. The principal streams in these areas are shown on Map 2.

History of Flooding

Floods have been a significant factor in the development of the subregion. The two general flood types are: 1) the late fall and winter months rainflood primarily as a result of prolonged general rainstorms in the mountain and valley floor areas; and 2) the spring and early summer months runoff primarily as a result of the melting of the winter snowpack in the Sierra Nevada. A description of the most noteworthy floods of the late 1800's and early 1900's is included in the Regional Summary of the appendix. A flood in 1932 caused 16 persons to lose their lives but damage records are not available for that time period. On a subregional basis, the 1955-1956, the 1966-1967 and the 1968-1969 floods are considered to be among the more severe, although other floods may have caused higher flows on individual streams.

During late December 1955, intense rainstorms in the subregion resulted in exceptionally large streamflows and subsequent flooding. Snowmelt added about 1 inch of water to the basin-mean runoff. About 183,000 acres were inundated (almost all agricultural lands) during the flood with damages totaling nearly $18 million.

During 1966-1967, floods claimed three lives and inundated about 142,000 acres. Resulting damages totaled $26.4 million with agricultural and public facility damages comprised over 65% of the total. Floodflows along the Kaweah and Tule Rivers are shown in Photos TB-I and TB-II.

Rain and snowmelt floods occurred in the Tulare Basin Subregion during the 1968-1969 flood season. Up to 50 inches of rain occurred in the upper portion of the Tulare Basin in January, and substantial but lesser amounts in February. These storms in addition to causing flooding left a snowpack of unprecedented depth and water content (220-340 percent of normal). The flood season was climaxed during the period April through July when near record snowmelt flooding inundated about 540,000 acres causing flood damages in excess of $76 million. Total volume of snowmelt for the subregion was estimated at 5,770,000 acre-feet which approached the previous record in 1906.

Flood fighting and cleanup costs under various Federal programs were about $0.9 million during the 1955-1956 flood and about $2.5 million for

Floodflows on South Fork Kaweah River near Three Rivers, December 1966. (Visalia Times-Delta Photo.)

PHOTO TB-I

Flooding along Tule River near Springville, December 1966. (Visalia Times-Delta Photo.)

PHOTO TB-II

the 1966-1967 flood. Damages from these and other significant, recent floods in the subregion are tabulated below and are shown in more detail in Tables 1 and 2.

Flood year	Forest & range resources & facilities	Agricultural & land	Residential & commercial	Industrial & utility	Public facilities	Total
	Flood damages 1/ ($1,000)					
1955-1956	1,376	5,859	5,501	989	4,270	17,985
1958	0	3,481	34	1	323	3,839
1962-1963	0	95	32	50	369	446
1966-1967	5,043	4,765	1,977	2,124	12,574	26,483
1968-1969	2,249	39,098	7,085	6,231	21,705	76,368

1/ Based on prices and project and economic conditions at time of occurrence of flood.

Peak flows of maximum floods of record, 100-year floods, and standard project floods for selected stations in the subregion are shown in Table 11.

Present Status of the Flood Control Improvements

The existing flood control improvements within the subregion comprise a variety of measures to reduce flood damages. (See Map 3.) They include flood forecasting, flood control reservoirs, floodwater retardation structures, locally owned levee systems, and tributary watershed treatment. Existing measures, which are described in more detail in following paragraphs, provide flood protection to 60% of the area subject to flooding. With a few exceptions (principally the locally owned levels), the degree of protection provided by existing flood control measures varies from 50-year or greater flood protection in urban areas, and from 10 to 50-year flood protection in agricultural areas.

River and flood forecasts are prepared and distributed by the Federal-State River Forecast Center in Sacramento. These include: 1) inflow forecasts for the major structures such as Pine Flat, Terminus, Success and Isabella Dams, 2) flood stage forecasts for urban areas above and below the dams as required, and 3) forecasts of volume of inflow into Tulare Lake during periods of high snowmelt.

During periods of heavy winter rainfall, warnings are issued for Springville, Three Rivers, and Kernville, and for Bakersfield and Porterville when upstream flows exceed channel capacity. Inflow forecasts to the reservoir are provided to aid in flood control operations during winter storm periods and the spring snowmelt period. Forecast points are indicated on Map 4.

Existing major flood control reservoirs in the subregion are operated to provide a maximum of 1,821,000 acre-feet of flood control storage during the most critical flood situations. (See Table 6). These projects are shown on Map 3. Success and Pine Flat Dams are shown in Photos TB-III and TB-IV. The existing flood control reservoirs are:

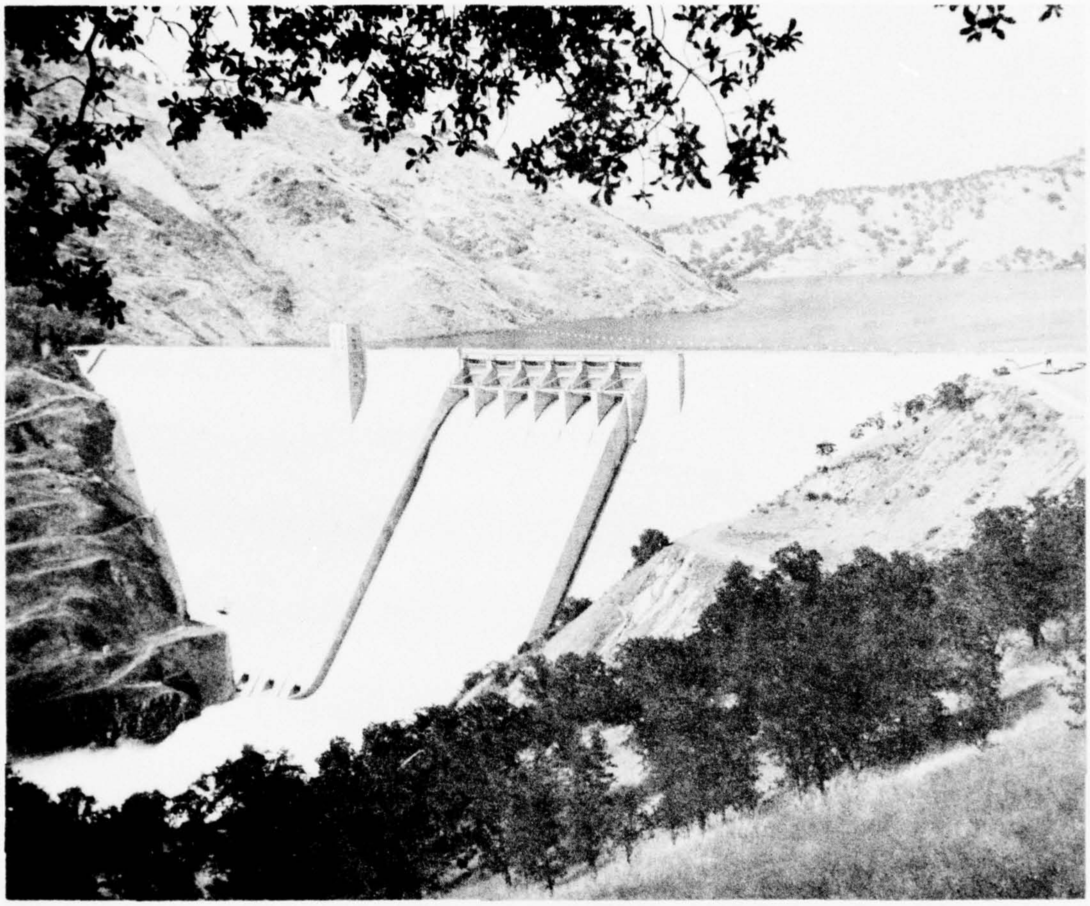
Study area	Reservoir	Stream	Flood control capacity (ac.-ft.)	Drainage area (sq. miles)
Kings River Basin	Pine Flat	Kings River	1,000,000	1,545
Fresno County Stream Group	Big Dry Creek	Big Dry Creek	16,000	86
Kaweah River Basin	Terminus	Kaweah River	150,000	560
Tule River Basin	Success	Tule River	85,000	391
Kern River Basin	Isabella	Kern River	570,000	2,074

Other reservoirs in the subregion, though not having flood control as a designated function, provide incidental, but often significant, flood control benefits. Reservoirs of this type are:

Reservoir	Stream	Construction agency
Courtright	Helms Creek	Pacific Gas & Electric Company
Wishon	North Fork Kings River	Pacific Gas & Electric Company

Success Dam and Reservoir on Tule River during the December 1966 flood. (United Aerial Survey Photo.)

PHOTO TB-III



Pine Flat Dam on Kings River. (Corps of Engineers Photo.)

PHOTO TB-IV

In tributary watershed areas, flood prevention work has been due entirely to private initiative and has been confined mostly to channel work, stabilization structures, levee construction, and basic land treatment measures.

The Flood Plain Management Services Program of the Corps of Engineers is covered in detail in the Regional Summary of this appendix. Under the program, flood hazard information is being furnished to local agencies for use in evaluating the flood hazard of individual sites.

The accomplishments of the existing flood control measures (and others that provide incidental flood control benefits) have been substantial. They have functioned effectively to reduce floodflows and resulting flood damage. The flood control system existing in 1965 would have prevented $23.0 million in flood damages during the 1955 flood and $15.5 million in flood damages during the 1958 flood. During the 1968-1969 flood season emergency work was accomplished under Operation Foresight due to the unprecedented snowpack conditions existing prior to the snowmelt flood period. The work consisted largely of channel clearing and strengthening, raising, extending and reinforcing existing levees on streams expected to be affected by the extremely heavy snowpack runoff. Most of the work was accomplished on non-Federal improvements. The capacities of Success and Terminus Reservoirs were temporarily increased by means of spillway barriers which resulted in a substantial reduction of floodflows. Generally the emergency protective measures were very effective and should be of continuing benefits because the facilities are to be maintained by local interests. The preventive measures taken resulted in benefits exceeding three times the costs expended. It is estimated that average annual damages prevented by existing measures exceeds $9.6 million. Additional details are included in Table 2.

Although the subregion currently is afforded a considerable degree of flood protection, flood problems still exist in some areas. Flooding along some of the rivers in the area result in damages to agricultural and urban properties. (See tabulation, Page TB-6.) The problems are especially serious in the Kings, Kaweah, Tule, and Kern River Basins; in the Caliente Creek Basin; and in the Poso and Westside Stream Groups.

In the valleys of the Tulare Basin Subregion considerable streambank erosion and land loss due to sloughing occurs in many areas. Streambank erosion can be found to a certain degree along 4,940 miles of stream channel, with 760 miles considered "serious". The average annual land loss damage due to streambank erosion throughout the subregion reaches $200,000. The land loss averages about 130 acres yearly of which about 25 percent is in urban areas. In the upstream watershed areas, sheet erosion on steeper lands is a constant threat. Tables 1, 3 and 4 show damage categories, listing land and forest and range resources. These two categories index the magnitude of the erosion problem for the subregion.

The aforementioned flood problems result in average annual damages summarized as follows:

Study area	Estimated average annual damage 1/ ($1,000)
Fresno County Stream Group	541
Kings River Basin	672
Kaweah River Basin	1,256
Tule River Basin	661
Poso Creek Stream Group	1,018
Kern River Basin	2,632
Caliente Creek Basin	1,162
Streams Tributary to Buena Vista Lake	169
Westside Stream Group-Tulare Basin	991
Tulare Lakebed	364
Total Tulare Basin Subregion	9,466

1/ Based on 1965 prices, economic conditions, and project conditions.

Additional details are contained in Tables 3 and 4 for the subregion as a whole and in Table 9 for urban areas. Major urban damage centers and areas of the subregion subject to flooding are shown on Map 4.

Future Needs

It is evident from an examination of current (1965) flood problems, additional flood control measures are required. Average annual flood damages (based on 1965 prices and conditions) amout to $9.5 million. The flood problems of the area will increase in the future due to the pressures of population and economic growth and resultant increases in use of flood plains. The population of the Tulare Basin Subregion is projected to increase from 906,000 in 1965 to 1,171,000 in 1980, 1,902,000 in 2000 and 3,454,000 in 2020 (base plan projections). Average annual flood damages are expected to increase to $14.2 million by 1980, to $23.7 million by 2000, and to $47.8 million by 2020 if additional flood control measures are not provided after 1965. Estimated damage data for existing and future conditions are contained in Tables 5 and 9a.

Measures Required to Satisfy Future Needs

Improved flood forecasting will be part of the comprehensive flood control program. The optimum operation of flood control projects can most nearly be obtained by a well-coordinated system of forecasting. The development of improved forecast procedures, particularly for snowmelt

periods, will be a high priority requirement. Such procedures will be required for coordinating releases from major reservoirs during high inflow periods. To do so, however, extensive supplementation of the hydrologic data collection and telemetering network must be effectuated. Emphasis must be placed on additional precipitation, temperature, and snow water sensors, particularly in the higher elevations. The required improvements to the flood forecasting system are estimated to cost $490,000 for the 1966-1980 period, $390,000 for the 1981-2000 period, and $340,000 for the 2001-2020 period.

Floodwater storage in reservoirs will be an important element future flood control program. An additional 1,687,000 acre-feet of flood control capacity are required in the subregion. See the following tabulation:

Study area/ time frame in which needed	Reservoir	Stream	Flood control capacity (ac.-ft.)	Drainage area (sq. miles)
Fresno County Stream Group				
1981-2000	Big Dry (enlargement)	Big Dry Creek	26,000	104
1981-2000	Owens Mountain	Little Dry Creek	600,000 1/	30
1981-2000	Detention Structure	No Name	1,000	6
Kings River Basin				
1981-2000	Piedra, Mill	Kings River, Mill Creek	150,000	1,707
1981-2000	Detention Structures (3)	(Various)	1,000	6
2001-2020	Rogers Crossing	Kings River	300,000	956
Kaweah River Basin				
1966-1980	Detention Structures (3)	(Various)	1,000	13
1981-2000	Detention Structures (2)	(Various)	2,000	31
2001-2020	South Fork Kaweah	Kaweah River	25,000	896
2001-2020	Limekiln	Limekiln Creek	20,000	80
Tule River Basin				
2001-2020	North & Middle Fork	Tule River	63,000	210

Study area/ time frame in which needed	Reservoir	Stream	Flood control capacity (ac.-ft.)	Drainage area (sq. miles)
Poso Creek Stream Group				
1981-2000	Hungry Hollow	Deer Creek	32,000	126
1981-2000	Poso	Poso Creek	40,000	298
1981-2000	Detention Structures (5)	(Various)	5,000	43
2001-2020	Quincy School	White River	25,000	98
2001-2020	Detention Structures (4)	(Various)	6,000	151
Kern River Basin				
1981-2000	Junction, Rockhouse	Kern River	220,000	1,090
2001-2020	Anthill	Kern River	50,000	2,384
Caliente Creek Basin				
1966-1980	Detention Structures (2)	(Various)	1,000	11
1981-2000	Detention Structures (11)	(Various)	19,000	443
2001-2020	Caliente Creek	Caliente Creek	50,000	743
Westside Stream Group-Tulare Basin				
1981-2000	Zapato, Nunez, Alcalde, Jacalito	Coalinga Group	37,000	295
1981-2000	Detention Structures (7)	(Various)	12,000	206
2001-2020	Detention Structures (2)	(Various)	1,000	10
		TOTAL	1,687,000	

1/ Offstream storage.

The reservoirs listed above are shown on Map 3 and additional information on flood control storage is contained in Table 6. Estimated costs for additional flood control capacity are estimated at $2.8 million for the 1966-1980 period, $141.9 million for the 1981-2000 period, and $81.6 million for the 2001-2020 period.

Preliminary studies indicate that levees and channel work is desirable in the following areas of the subregion:

Study area	Levees (Bank Miles)	Channels (Miles)
Fresno County Stream Group		
1981-2000	0	44
Kings River Basin		
1966-1980	30	60
Kaweah River Basin		
1966-1980	0	23
Poso Creek Stream Group		
1981-2000	0	50
2001-2020	0	8
Caliente Creek Basin		
1966-1980	10	3
2001-2020	30	50
Westside Stream Group-Tulare Basin		
1981-2000	8	12
2001-2020	0	11
TOTAL	78	261

The approximate location of levees and channel work is indicated on Map 3 and additional details are included in Table 7. The estimated costs for required levee and channel work are $15.0 million for the 1966-1980 period, $9.7 million for the 1981-2000 period, and $10.9 million for the 2001-2020 period.

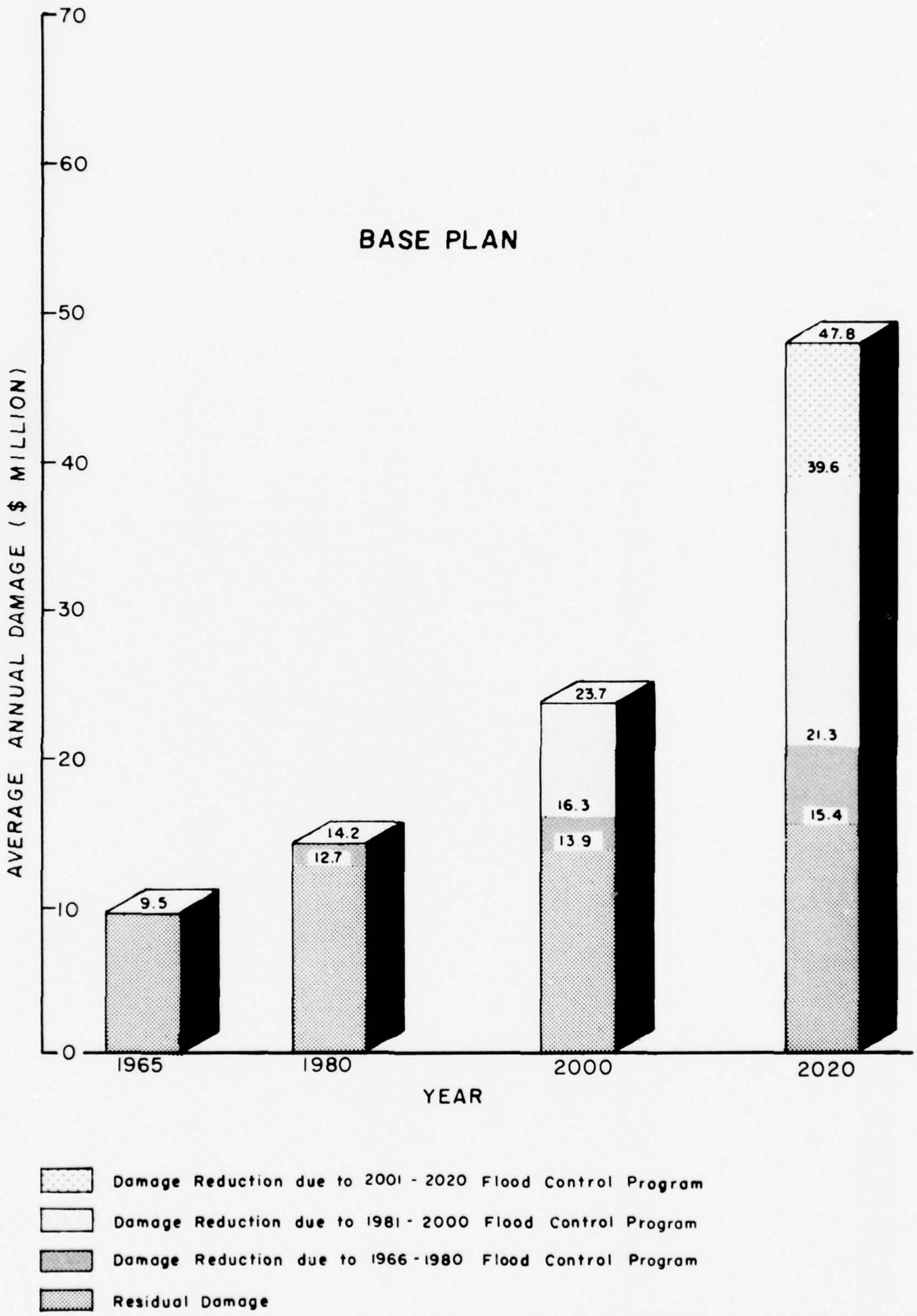
The structural measures discussed in the preceeding paragraphs will be complemented by non-structural land treatment measures for soil and water conservation. In this subregion, the land treatment measures will include most of the practices listed in the Regional Summary of this appendix. See Map 3 for potential watershed project. Estimated costs and acres of watershed and treatment measures are tabulated below.

Land Treatment	1966-1980	1981-2000	2001-2020
Thousand acres	47	96	443
Thousand dollars	1,200	3,100	1,800

Flood plain zoning, flood proofing and other non-structural flood plain management measures have been incorporated in the future flood control program. Fresno County Stream Group and Caliente Creek Basin are the primary areas considered in the 1966-1980 time frame. After 1980 Kaweah River Basin and Caliente Creek Basin would receive most consideration for such measures. Table 9b shows damages reduced by such non-structural measures for urban areas in the subregion. Communities with populations in excess of 2,500 with known significant flood problems include Bakersfield, Clovis, Coalinga, Exeter, Ford City, Taft, Fresno, Kernville, Lamont, Lindsay, Mendota, Porterville, Reedley, Tulare, and Visalia. Many communities with expanding populations are expected to have flood problems in the future and will be studied as their needs are made known. Flood plain information reports for Kaweah, Kern, and Tule Rivers; Fresno County Stream Group; Caliente Creek Group; and Streams Tributary to Buena Vista Lake; are scheduled for completion by 1980. It is anticipated that flood plain information reports for all the communities named above will be completed before the year 2000. Comprehensive flood damage prevention planning and implementation of flood plain management measures would follow in each flood problem area identified. Non-structural flood plain management measures along approximately 140 stream miles could be implemented for urban areas including the above listed communities. Map 3 shows principal areas for which non-structural flood plain management measures are proposed. Costs for future non-structural flood plain management measures are estimated at $10.7 million for the 1966-1980 period, $4.4 million for the 1981-2000 period, and $19.8 million for the 2001-2020 period.

Potential to Satisfy Future Needs

The flood control program presented herein would reduce the projected average annual damages $1.5 million by 1980, $9.8 million by 2000, and $32.4 million by 2020 at an estimated installation cost of $30.2 million for the period 1966-1980, $159.5 million for 1981-2000, and $114.4 million for 2001-2020. Estimated annual OM&R costs for the 1966-1980, 1981-2000 and 2001-2020 portion of the flood control program are $0.60 million, $1.24 million and $1.19 million (See Tables 10, 10a and 10b). The effect of the potential flood control program on future damages is shown in Table 8 and graphically on Figure TB-I, and its effect on flood flows is shown in Table 11.



CALIFORNIA REGION
COMPREHENSIVE FRAMEWORK STUDY

PROJECTED AVERAGE ANNUAL FLOOD DAMAGES

(1965 PRICES AND PROJECT CONDITIONS—DATA FROM TABLES 5 & 8)

APPENDIX IX

FIGURE TB-1

TABLE 1

TULARE BASIN SUBREGION OF THE CALIFORNIA REGION

Historical Flood Data

Study area	Flood	Location/ flow (cfs)	Area inundated (1,000 acres)	Flood damages 1/ - ($1,000) Forest & range resources	Forest & range facilities	Crop & pasture	Other agricultural	Land	Residential & commercial	Industrial & utility	Public facilities	Total
1	2	3	4	5	6	7	8	9	10	11	12	13
Fresno County Stream Group	Mar38	Big Dry site 2,600	31.8	0	0	8	8	25	390	30	54	515
Kings River Basin	Dec37	Pine Flat 80,000	58.0	11	1,145	372	33	6	27	232	54	1,880
	Nov50	Pine Flat 91,000	69.3	13	1,328	2,252	31	31	203	914	516	5,288
Kaweah River Basin	Dec55	Near Three Rivers 80,700	126.2	42	343	988	1,976	834	5,332	822	3,407	13,744
	Dec66	Terminus Inflow 105,000 (Outflow 5,700)	1.7	22	2,359	203	399	72	744	294	1,159	5,252
Tule River Basin	Nov50	Worth Bridge 28,000	49.0	0	25	103	354	87	186	229	235	1,219
	Dec55	Worth Bridge 24,700	38.0	8	983	238	814	200	116	145	412	2,916
	Dec66	Success Inflow 61,000 (Outflow 8,300)	26.3	14	1,694	209	729	181	447	660	3,173	7,107
Poso Creek Stream Group	Mar43	Poso Cr. Hwy 99 10,000	34.6	1	21	302	244	34	0	0	448	1,050
	Dec66	Poso Cr. near Oildale 4,300	13.9	2	144	231	285	102	5	99	576	1,444
Kern River Basin	Nov50	Isabella site 39,000	37.3	0	134	163	383	213	192	256	790	2,131
	Dec66	Isabella Inflow 120,000 (Outflow 400)	20.6	33	720	289	185	167	564	662	2,218	4,838
Caliente Creek Basin	Sep32	Sivert Damsite 16,000	10.0	14	0	0	0	70	47	859	50	1,040
	Dec66	Sivert Damsite 3,800	11.7	50	0	94	336	241	143	117	198	1,179
Streams Tributary to Buena Vista Lake	Apr58	Varied				No historical flood data						
Westside Stream Group - Tulare Basin	Dec66	Los Gatos Creek 4,800	19.2	5	0	297	18	43	0	228	101	692
Tulare Lakebed	Jan-Mar 06	Tulare Lake Inflow 2,010,000 ac-ft	193.0			Damage data not available						
	1938	Tulare Lake Inflow 1,195,000 ac-ft	78.0	0	0	4,229	1,784	0	0	2,837	70	8,920
	Jun69	961,800 ac-ft			Damages currently being assessed - expected to exceed $20,000,000							

1/ Data based on prices and project and economic conditions at time of occurrence of flood.

TABLE 2

TULARE BASIN SUBREGION OF THE CALIFORNIA REGION

Flood Damage 1/

Study area	Flood	Location/ flow (cfs)	Total damages - ($1,000)					
			At time of flood 2/			1965 economic conditions & prices 3/		
			Actual damage	Damage without flood control projects	Damage prevented by flood control projects 4/	Damage with 1965 project conditions	Damage without flood control projects	Damage prevented by 1965 projects 5/
1	2	3	4	5	6	7	8	9
Fresno County Stream Group	Dec55	Dry Creek Inflow 3,800 (Outflow 80)	46	3,046	3,000	126	8,326	8,200
Kings River Basin	Dec55	Pine Flat Inflow 112,000 (Outflow 240)	297	5,297	5,000	2,158	15,058	12,900
Kaweah River Basin	Dec66	Terminus Inflow 105,000 (Outflow 5,700)	5,252	25,188	19,936	5,146	27,196	22,050
Tule River Basin	Dec66	Success Inflow 61,000 (Outflow 8,300)	7,107	18,787	11,680	6,965	18,411	11,446
Poso Creek Stream Group	Dec66	Poso Creek near Oildale 4,300	1,444	1,444	0	1,416	1,416	0
Kern River Basin	Dec66	Isabella Inflow 120,000 (Outflow 400)	4,838	54,859	50,021	4,745	53,765	49,020
Caliente Creek Basin	Dec66	Sivert Damsite 3,800	1,179	1,179	0	1,155	1,155	0
Streams Tributary to Buena Vista Lake	Apr58		No flood damage data					
Westside Stream Group - Tulare Basin	Dec66	Los Gatos Creek 4,800	692	1,192	500	1,168	1,168	0
Tulare Lakebed	1938	Tulare Lake Inflow 1,195,000 ac-ft	8,920	8,920	0	2,300	18,600	16,300
	Jun69	961,800 ac-ft	Damages currently being assessed - expected to exceed $20,000,000					

1/ Maximum flood for which data are available.
2/ Data based on prices and project and economic conditions at time of occurrence of flood.
3/ Data based on recurrence of originel flood.
4/ Column 6 = column 5 - column 4.
5/ Column 9 = column 8 - column 7.

TABLE 3

TULARE BASIN SUBREGION OF THE CALIFORNIA REGION

Estimated Flood Damage for
the 100-Year Frequency Flood 1/
for Selected Streams

Study area stream	Area inundated (1,000 acres)	Flood damage 2/ - ($1,000) Forest & range resources	Forest & range facilities	Crop & pasture	Other agricultural	Land	Residential & commercial	Industrial & utilities	Public facilities	Total
1	2	3	4	5	6	7	8	9	10	11
Fresno County Stream Group Red Bank & Fancher Creeks	18.4	0	0	1,214	64	107	8,365	860	2,690	13,300
Kings River Basin Kings River	29.3	7	756	3,914	204	585	488	235	761	6,950
Kaweah River Basin Kaweah River	85.7	56	451	1,134	909	2,018	3,249	1,250	4,423	13,490
Tule River Basin Tule River	22.4	14	1,694	54	353	244	1,359	322	1,380	5,420
Poso Creek Stream Group Poso Creek	132.2	5	424	1,879	1,734	963	510	555	2,734	8,804
Kern River Basin Kern River	68.9	130	9,074	377	346	570	2,288	564	997	14,346
Caliente Creek Basin Caliente Creek	27.3	78	0	210	563	745	3,083	2,548	1,053	8,300
Streams Tributary to Buena Vista Lake San Emigdio Creek	25.9	0	360	824	49	349	76	38	104	1,800
Westside Stream Group-Tulare Basin Coalinga Stream Group	102.0	27	0	1,857	654	920	1,654	416	2,177	7,705
Tulare Lakebed Tulare Lake	94.0	0	0	7,750	3,095	0	0	20	35	10,900

1/ See Table 11 for magnitude of 100-year flood at selected stations.
2/ Based on July 1965 prices, economic conditions, and project conditions.

TABLE 4

TULARE BASIN SUBREGION OF THE CALIFORNIA REGION

Estimated Average Annual Flood Damage

Study area (principal stream)	Flood damage 1/ - ($1,000)								
	Forest & range resources	Forest & range facilities	Crop & pasture	Other agricultural	Land	Residential & commercial	Industrial & utilities	Public facilities	Study area totals
1	2	3	4	5	6	7	8	9	10
Fresno County Stream Group (Red Bank & Fancher Creek)	0	0	59	32	7	318	29	96	541
Kings River Basin (Kings River)	1	151	144	42	150	54	19	111	672
Kaweah River Basin (Kaweah River)	11	90	290	220	273	103	57	212	1,256
Tule River Basin (Tule River)	3	339	12	85	69	68	16	69	661
Poso Creek Stream Group (Poso Creek)	1	85	240	209	225	28	36	194	1,018
Kern River Basin (Kern River)	26	1,815	117	116	183	247	59	69	2,632
Caliente Creek Basin (Caliente Creek)	16	0	75	140	205	357	257	112	1,162
Streams Tributary to Buena Vista Lake (San Emigdio Creek)	0	72	55	3	23	7	3	6	169
Westside Stream Group - Tulare Basin (Coalinga Stream Group)	6	0	259	178	233	124	31	160	991
Tulare Lakebed (Tulare Lake)	0	0	259	103	0	0	1	1	364
Total Tulare Basin Subregion	64	2,552	1,510	1,128	1,368	1,306	508	1,030	9,466

1/ Damages based on July 1965 prices, economic conditions, and project conditions.

TABLE 5

TULARE BASIN SUBREGION OF THE CALIFORNIA REGION

Summary of Estimated Average Annual Flood Damage for Present and Future Conditions of Economic Development with Existing Flood Control Measures

Study area (principal stream)	Average annual flood damages 1/ - ($1,000)			
	1965 economic conditions 2/	1980 economic conditions	2000 economic conditions	2020 economic conditions
1	2	3	4	5
Fresno County Stream Group (Red Bank & Fancher Creeks)	541	1,051	2,543	7,162
Kings River Basin (Kings River)	672	956	1,394	2,228
Kaweah River Basin (Kaweah River)	1,256	1,888	2,790	4,806
Tule River Basin (Tule River)	661	949	1,522	2,898
Poso Creek Stream Group (Poso Creek)	1,018	1,562	2,629	5,145
Kern River Basin (Kern River)	2,632	3,342	4,469	6,485
Caliente Creek Basin (Caliente Creek)	1,162	1,952	4,135	10,693
Streams Tributary to Buena Vista Lake (San Emigdio Creek)	169	242	348	552
Westside Stream Group-Tulare Basin (Coalinga Stream Group)	991	1,697	3,098	6,726
Tulare Lakebed (Tulare Lake)	364	576	806	1,080
Total Tulare Basin Subregion	9,466	14,215	23,734	47,775

1/ Damages based on July 1965 prices and project conditions, and estimated economic conditions for the year shown.
2/ Figures in column 2 are from column 10 of Table 4.

TABLE 6

TULARE BASIN SUBREGION OF THE CALIFORNIA REGION

Summary of Flood Control Capacity for Existing and Future Reservoirs

Study area	Flood control capacity 1/ - (1,000 ac-ft)				
	Existing projects (1965)	Projects 1966-1980 2/	Projects 1981-2000 2/	Projects 2001-2020 2/	Total projects as of 2020
1	2	3	4	5	6
Fresno County Stream Group	16	0	627 3/	0	643
Kings River Basin	1,000	0	151	300	1,451
Kaweah River Basin	150	1	2	45	198
Tule River Basin	85	0	0	63	148
Poso Creek Stream Group	0	0	77	31	108
Kern River Basin	570	0	220	50	840
Caliente Creek Basin	0	1	19	50	70
Westside Stream Group - Tulare Basin	0	0	49	1	50
Total Tulare Basin Subregion	1,821	2	1,145	540	3,508

1/ Maximum flood control capacity. Does not include surcharge storage.
2/ Includes only reservoirs controlling the 100-year flood, or better, at the damsite above urban areas and reservoirs controlling at least the 10-year flood at the damsite where only rural areas are to be protected.
3/ **Includes 600,000 acre-feet at Owens Mountain offstream storage project.**

TABLE 7

TULARE BASIN SUBREGION OF THE CALIFORNIA REGION

Summary of Levee and Channel Flood Protection Projects
- Existing and Future -

Study area	Levee and channel projects									
	Existing projects (1965) 1/		Projects 1966-1980 2/		Projects 1981-2000 2/		Projects 2001-2020 2/		Total project as of 2020	
	Levees (miles)	Channels (miles)	Levees (miles)	Channels (miles)	Levees (miles)	Channels (miles)	Levees (miles)	Channels (miles)	Levees (miles)	Channels (miles)
1	2	3	4	5	6	7	8	9	10	11
Fresno County Stream Group	0	0	0	0	0	44	0	0	0	44
Kings River Basin	0	0	30	60 4/	0	0	0	0	30	60 4/
Kaweah River Basin	0	0	0	23	0	0	0	0	0	23
Poso Creek Stream Group	0	0	0	0	0	50	0	8	0	58
Kern River Basin	0	0	0	3/	0	0	0	0	0	3/
Caliente Creek Basin	0	0	10	3	0	0	30	50	40	53
Westside Stream Group-Tulare Basin	0	0	0	0	8	12	0	11	8	23
Total Tulare Basin Subregion	0	0	40	86	8	106	30	69	78	261

1/ Does not include locally owned levee systems which provide varying degrees of flood protection.
2/ Includes only projects giving 100-year flood protection, or better, to urban areas and at least 10-year flood protection to agricultural areas.
3/ Intertie structure between Kern River and California Aqueduct - Capacity 3,000 c.f.s.
4/ Intermittent.

TABLE 8

TULARE BASIN SUBREGION OF THE CALIFORNIA REGION

Estimated Average Annual Flood Damage and Damage Reduction
- Present and Future Economic Conditions -

Study area (principal stream)	Total damages - 1965 prices ($1,000)									
	1965 economic & project conditions 1/	1980 economic conditions			2000 economic conditions			2020 economic conditions		
		W/1965 project conditions 2/	Reduction in damages due to 1966-1980 flood control program 3/	Residual damage W/ 1966-1980 program 4/	W/1966-1980 program	Reduction in damages due to 1981-2000 flood control program 3/	Residual damage W/ 1981-2000 program 5/	W/1981-2000 program	Reduction in damages due to 2001-2020 flood control program 3/	Residual damage W/ 2001-2020 program 6/
1	2	3	4	5	6	7	8	9	10	11
Fresno County Stream Group (Red Bank & Fancher Creeks)	541	1,051	297	754	2,246	1,956	290	1,337	723	614
Kings River Basin (Kings River)	672	956	34	922	1,334	159	1,175	1,847	601	1,246
Kaweah River Basin (Kaweah River)	1,256	1,888	474	1,414	2,109	103	2,006	3,496	1,175	2,321
Tule River Basin (Tule River)	661	949	0	949	1,522	0	1,522	2,898	1,252	1,646
Poso Creek Stream Group (Poso Creek)	1,018	1,562	0	1,562	2,629	1,045	1,584	2,968	1,157	1,811
Kern River Basin (Kern River)	2,632	3,342	36	3,306	4,392	577	3,815	5,205	825	4,380
Caliente Creek Basin (Caliente Creek)	1,162	1,952	469	1,483	3,182	687	2,495	4,167	1,533	2,634
Streams Tributary to Buena Vista Lake (San Emigidio Creek)	169	242	4	238	343	17	326	518	68	450
Westside Stream Group-Tulare Basin (Coalinga Stream Group)	991	1,697	102	1,595	2,865	2,769	96	436	250	186
Tulare Lakebed (Tulare Lake)	364	576	106	470	658	102	556	767	644	123
Total Tulare Basin Subregion	9,466	14,215	1,522	12,693	21,280	7,415	13,865	23,639	8,228	15,411

1/ Figures shown in column 2 are from column 10 of Table 4 and are also shown in column 2 of Table 5.
2/ Figures in column 3 are from column 3 of Table 5.
3/ Includes structural and non-structural measures.
4/ Column 5 = column 3 - column 4.
5/ Column 8 = column 6 - column 7.
6/ Column 11 = column 9 - column 10.

TABLE 9

TULARE BASIN SUBREGION OF THE CALIFORNIA REGION

Estimated Average Annual Flood Damage for Urban Areas with Significant Flood Problems

Study area/ stream	Damage center	Average annual flood damages ($1,000) 1/ Residential	Commercial	Industrial & utilities	Public facilities	Total
1	2	3	4	5	6	7
Fresno County Stream Group						
Red Bank, Fancher & Big Dry Creeks	Fresno	192	95	23	75	385
Kings River Basin						
Kings River & Panoche Creek	Mendota	1	1	2	1	5
Kings River, Wahtoke and Travers Creeks	Reedley	2	1	1	2	6
Kaweah River Basin						
Kaweah River	Visalia	20	15	5	9	49
Kaweah River	Tulare	2	1	0	1	4
Lewis Creek	Lindsay	11	1	3	0	15
Yokohl Creek	Exeter	1	4	1	4	10
Tule River Basin						
Tule River	Porterville	25	15	5	6	51
Kern River Basin						
North Fork Kern River	Kernville	1	7	4	6	18
Kern River	Bakersfield	15	20	9	4	48
Caliente Stream Group						
Caliente & Walker Basin Creeks	Lamont	38	19	1	5	63
Streams Tributary to Buena Vista Lake						
Sandy Creek	Ford, Taft City	3	1	1	3	8
Westside Stream Group-Tulare Basin						
Los Gatos & Jacalitos Creeks	Coalinga	46	34	12	23	115
Total Tulare Basin Subregion		357	214	67	139	777

1/ Damages are based on July 1965 prices, economic conditions, and project conditions.

TABLE 9a

TULARE BASIN SUBREGION OF THE CALIFORNIA REGION

Summary of Estimated Average Annual Flood Damage for Urban Areas with Significant Flood Problems
- Present and Future Conditions of Economic Development
with Existing Flood Control Measures -

Study area/ stream	Damage center	Average annual flood damages 1/ - ($1,000) 1965 economic conditions 2/	1980 economic conditions	2000 economic conditions	2020 economic conditions
1	2	3	4	5	6
Fresno County Stream Group					
Red Bank, Fancher and Big Dry Creeks	Fresno & Clovis	385	803	2,128	6,346
Kings River Basin					
Panoche Creek	Mendota	5	10	25	69
Wahtoke Creek	Reedley	6	12	31	91
Kaweah River Basin					
Kaweah River	Visalia	49	96	228	647
Kaweah River	Tulare	4	8	19	54
Lewis Creek	Lindsay	15	30	72	197
Yokohl Creek	Exeter	10	19	44	126
Tule River Basin					
Tule River	Porterville	51	102	241	683
Kern River Basin					
Kern River	Kernville	18	32	77	236
Kern River	Bakersfield	48	89	218	674
Caliente Creek Basin					
Caliente Creek	Lamont	63	114	293	949
Streams Tributary to Buena Vista Lake					
Sandy Creek	Ford & Taft City	8	13	34	109
Westside Stream Group-Tulare Basin					
Los Gatos & Warthan Creeks	Coalinga	115	238	626	1,854
Total Tulare Basin Subregion		777	1,566	4,036	12,035

1/ Damages based on July 1965 prices and project conditions, and estimated economic conditions for the year shown.
2/ Figures in column 3 are from column 7, "Total," shown on Table 9.

TABLE 9b

TULARE BASIN SUBREGION OF THE CALIFORNIA REGION

Estimated Average Annual Flood Damage and Damage Reduction
for Urban Areas with Significant Flood Problems
- Present and Future Economic Conditions -

Study area/ stream	Damage center	Total damages - 1965 prices ($1,000): 1965 economic & project conditions 1/	1980 economic conditions: W/1965 project conditions 2/	1980: Reduction due to 1966-1980 program: Non-structural measures	1980: Reduction due to 1966-1980 program: Structural measures	1980: Residual damage w/1966-1980 program 3/	2000 economic conditions: W/1966-1980 program	2000: Reduction due to 1981-2000 program: Non-structural measures	2000: Reduction due to 1981-2000 program: Structural measures	2000: Residual damage w/1981-2000 program 4/	2020 economic conditions: W/1981-2000 program	2020: Reduction due to 2001-2020 program: Non-structural measures	2020: Reduction due to 2001-2020 program: Structural measures	2020: Residual damage w/2001-2020 program 5/
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Fresno County Stream Group														
Red Bank, Fancher, & Big Dry Creeks	Fresno & Clovis	385	803	297	0	506	1,341	0	979	362	1,079	0	550	529
Kings River Basin														
Panoche Creek	Mendota	5	10	4	0	6	21	12	0	9	53	40	0	13
Wahtoke Creek	Reedley	6	12	5	0	7	26	15	0	11	71	54	0	17
Kaweah River Basin														
Kaweah River	Visalia	49	96	0	0	96	228	0	0	228	647	0	533	114
Kaweah River	Tulare	4	8	0	0	8	19	0	0	19	54	0	42	12
Lewis Creek	Lindsay	15	30	12	0	18	60	33	0	27	152	115	0	37
Yokohl Creek	Exeter	10	19	7	0	12	37	20	0	17	99	75	0	24
Tule River Basin														
Tule River	Porterville	51	102	0	0	102	241	0	0	241	683	0	621	62
Kern River Basin														
Kern River	Kernville	18	32	0	0	32	77	0	61	16	49	0	0	49
Kern River	Bakersfield	48	89	15	0	74	181	0	98	83	256	0	238	18
Caliente Creek Basin														
Caliente Creek	Lamont	63	114	41	0	73	252	143	0	109	763	0	739	24
Streams Tributary to Buena Vista Lake														
Sandy Creek	Ford & Taft Cities	8	13	4	0	9	30	17	0	13	88	68	0	20
Westside Stream Group-Tulare Basin														
Los Gatos & Warthan Creeks	Coalinga	115	238	98	0	140	528	0	500	28	83	0	0	83
Total Tulare Basin Subregion		777	1,566	483	0	1,083	3,041	240	1,638	1,163	4,077	352	2,723	1,002

1/ Figures shown in column 3 are from column 7 of Table 9 and are also shown in column 3 of Table 9a.
2/ Figures in column 4 are from column 4 of Table 9a.
3/ Column 7 = column 4 - column 5 - column 6.
4/ Column 11 = column 8 - column 9 - column 10.
5/ Column 15 = column 12 - column 13 - column 14.

TABLE 10

TULARE BASIN SUBREGION OF THE CALIFORNIA REGION

Estimated Costs of Future Flood Control Program
- 19[illegible] to 198[illegible] -
($1,000)

Study area	Levees & channels				Flood control reservoirs				Non-structural measures			
	Federal		Non-Federal		Federal		Non-Federal		Federal		Non-Federal	
	Installation costs	Annual OM&R costs	Installation costs	Annual OM&R costs	Installation costs	Annual OM&R costs	Installation costs	Annual OM&R costs	Installation costs	Annual OM&R costs	Installation costs	Annual OM&R costs
1	2	3	4	5	6	7	8	9	10	11	12	13
Fresno County Stream Group	0	0	0	0	0	0	0	0	110	13	6,660	47
Kings River Basin	5,850	0	3,150	24	0	0	0	0	180	70	420	57
Kaweah River Basin	1,820	0	590	11	1,070	0	130	4	140	37	510	46
Tule River Basin	0	0	0	0	0	0	0	0	50	15	40	10
Poso Creek Stream Group	0	0	0	0	0	0	0	0	50	12	80	15
Kern River Basin	880	0	10	1	0	0	0	0	180	46	480	35
Caliente Creek Basin	2,390	0	310	51	1,500	0	60	7	20	3	1,030	13
Streams Tributary to Buena Vista Lake	0	0	0	0	0	0	0	0	20	4	150	10
Westside Stream Group-Tulare Basin	0	0	0	0	0	0	0	0	100	12	2,170	36
Tulare Lakebed	0	0	0	0	0	0	0	0	20	8	20	8
Total Tulare Basin Subregion	10,940	0	4,060	87	2,570	0	190	11	870	220	11,560	277

Base Plan

TABLE 10a

TULARE BASIN SUBREGION OF THE CALIFORNIA REGION

Estimated Costs of Future Flood Control Program
- 1981 to 2000 -
($1,000)

Study area	Levees & channels				Flood control reservoirs				Non-structural measures			
	Federal		Non-Federal		Federal		Non-Federal		Federal		Non-Federal	
	Installation costs	Annual OM&R costs	Installation costs	Annual OM&R costs	Installation costs	Annual OM&R costs	Installation costs	Annual OM&R costs	Installation costs	Annual OM&R costs	Installation costs	Annual OM&R costs
1	2	3	4	5	6	7	8	9	10	11	12	13
Fresno County Stream Group	3,070	0	1,470	33	60,240	77	300	5	70	26	130	30
Kings River Basin	0	0	0	0	36,080	49	280	8	310	134	860	112
Kaweah River Basin	0	0	0	0	710	0	310	3	160	65	1,160	56
Tule River Basin	0	0	0	0	0	0	0	0	100	30	90	21
Poso Creek Stream Group	2,640	0	600	18	5,260	31	610	7	90	23	210	35
Kern River Basin	0	0	0	0	14,250	38	0	0	390	98	410	76
Caliente Creek Basin	0	0	0	0	7,330	0	1,120	28	70	8	2,740	28
Streams Tributary to Buena Vista Lake	0	0	0	0	0	0	0	0	50	10	420	22
Westside Stream Group-Tulare Basin	1,250	0	680	11	14,810	16	640	23	180	29	400	62
Tulare Lakebed	0	0	0	0	0	0	0	0	10	12	10	12
Total Tulare Basin Subregion	6,960	0	2,750	62	138,680	211	3,260	74	1,430	435	6,430	454

TABLE 10b

TULARE BASIN SUBREGION OF THE CALIFORNIA REGION

Estimated Costs of Future Flood Control Program
- 2001 to 2020 -
($1,000)

Study area	Levees & channels				Flood control reservoirs				Non-structural measures			
	Federal		Non-Federal		Federal		Non-Federal		Federal		Non-Federal	
	Installation costs	Annual OM&R costs	Installation costs	Annual OM&R costs	Installation costs	Annual OM&R costs	Installation costs	Annual OM&R costs	Installation costs	Annual OM&R costs	Installation costs	Annual OM&R costs
1	2	3	4	5	6	7	8	9	10	11	12	13
Fresno County Stream Group	0	0	0	0	0	0	0	0	50	31	90	30
Kings River Basin	0	0	0	0	31,500	40	0	0	230	117	4,670	129
Kaweah River Basin	0	0	0	0	10,530	23	0	0	160	74	7,540	80
Tule River Basin	0	0	0	0	15,070	22	0	0	70	38	1,550	28
Poso Creek Stream Group	1,150	0	150	27	3,860	12	200	4	60	21	130	26
Kern River Basin	0	0	0	0	7,000	17	0	0	270	114	5,740	84
Caliente Creek Basin	5,000	0	2,620	65	11,880	19	0	0	30	8	50	12
Streams Tributary to Buena Vista Lake	0	0	0	0	0	0	0	0	40	8	910	19
Westside Stream Group-Tulare Basin	1,910	0	40	44	1,540	0	40	6	110	21	240	41
Tulare Lakebed	0	0	0	0	0	0	0	0	10	16	10	16
Total Tulare Basin Subregion	8,060	0	2,810	136	81,380	133	240	10	1,030	448	20,930	465

June 1971

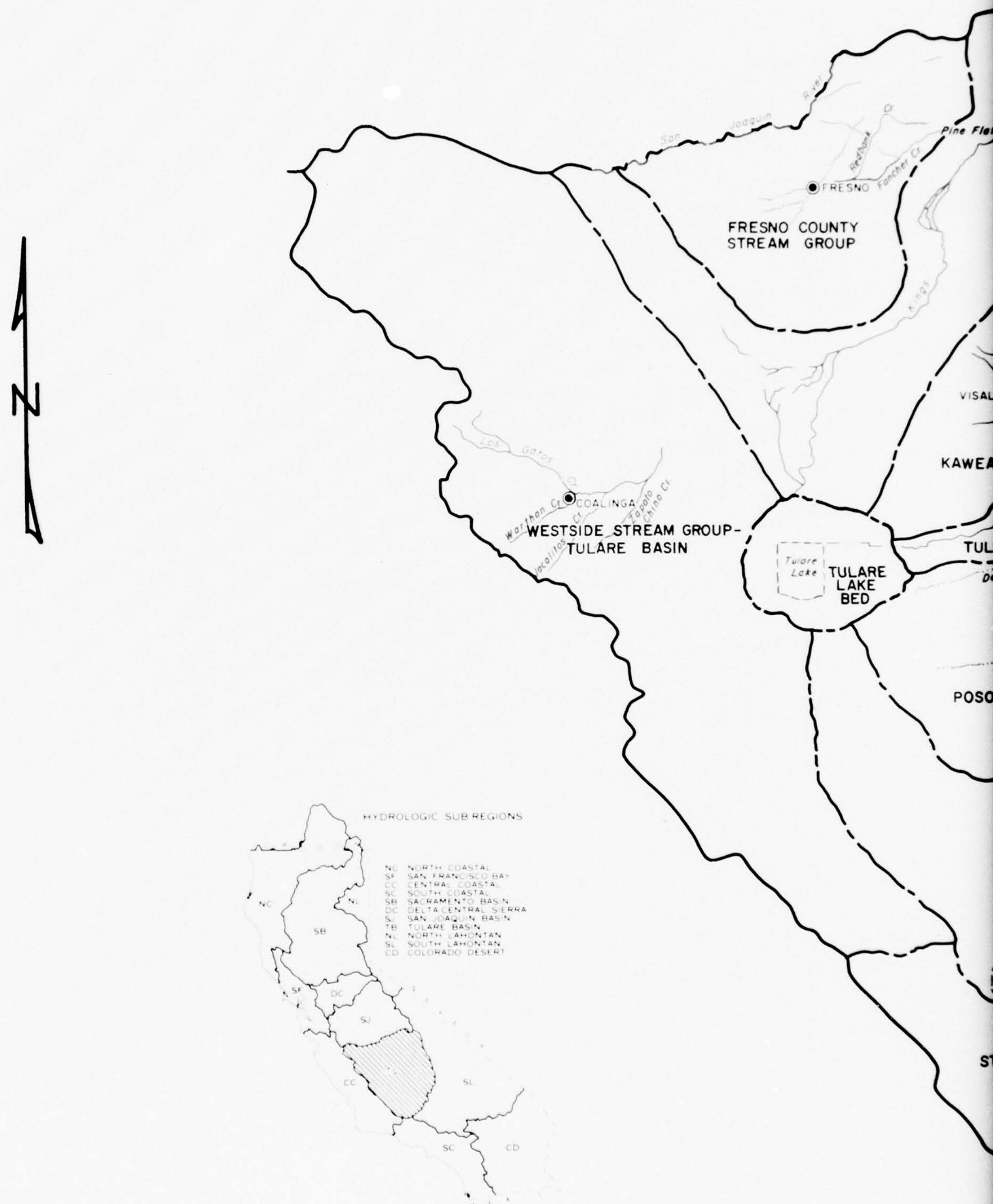
TABLE 11

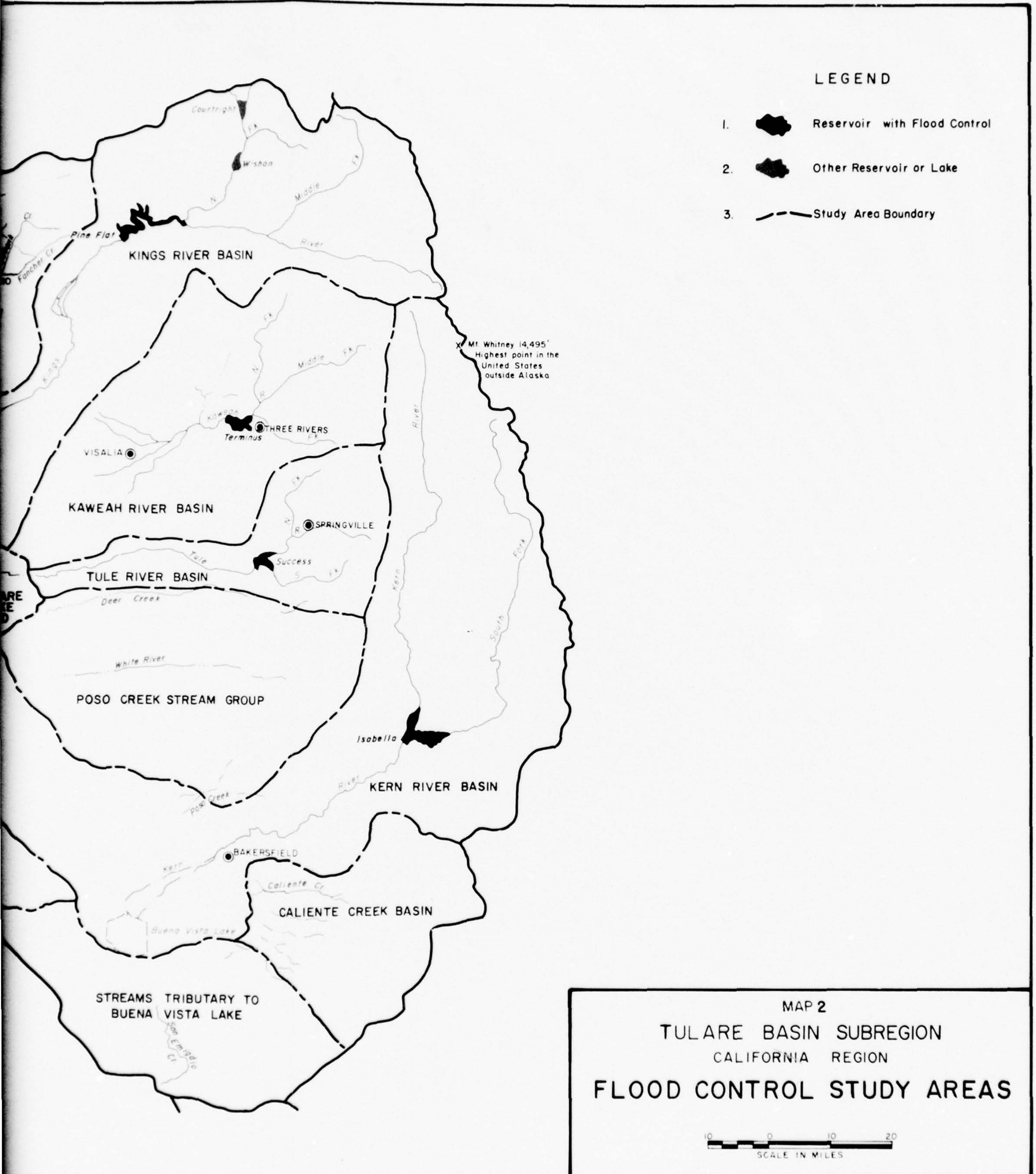
TULARE BASIN SUBREGION OF THE CALIFORNIA REGION

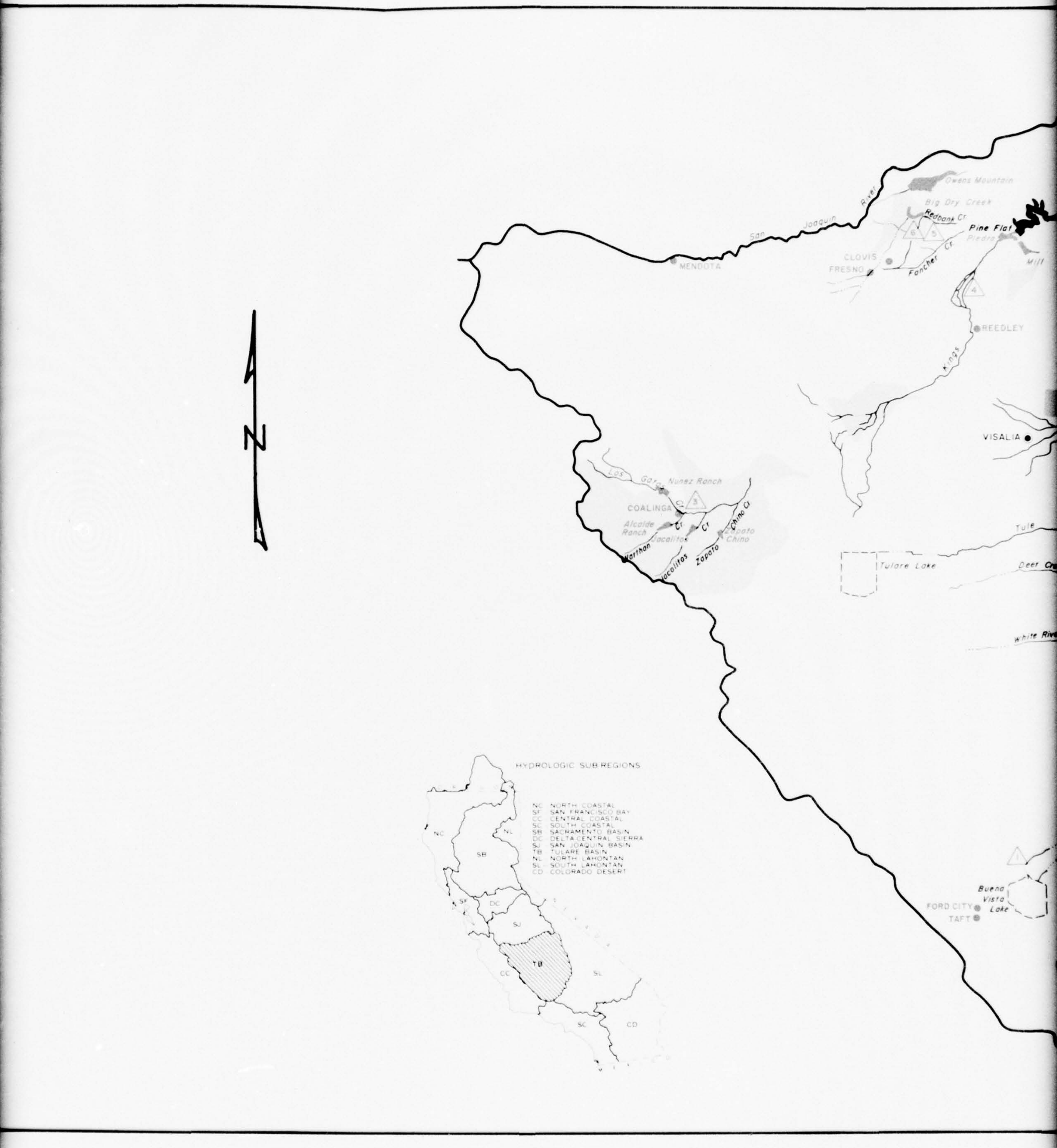
Flow Data at Selected Locations
(Flows in 1,000 cfs)

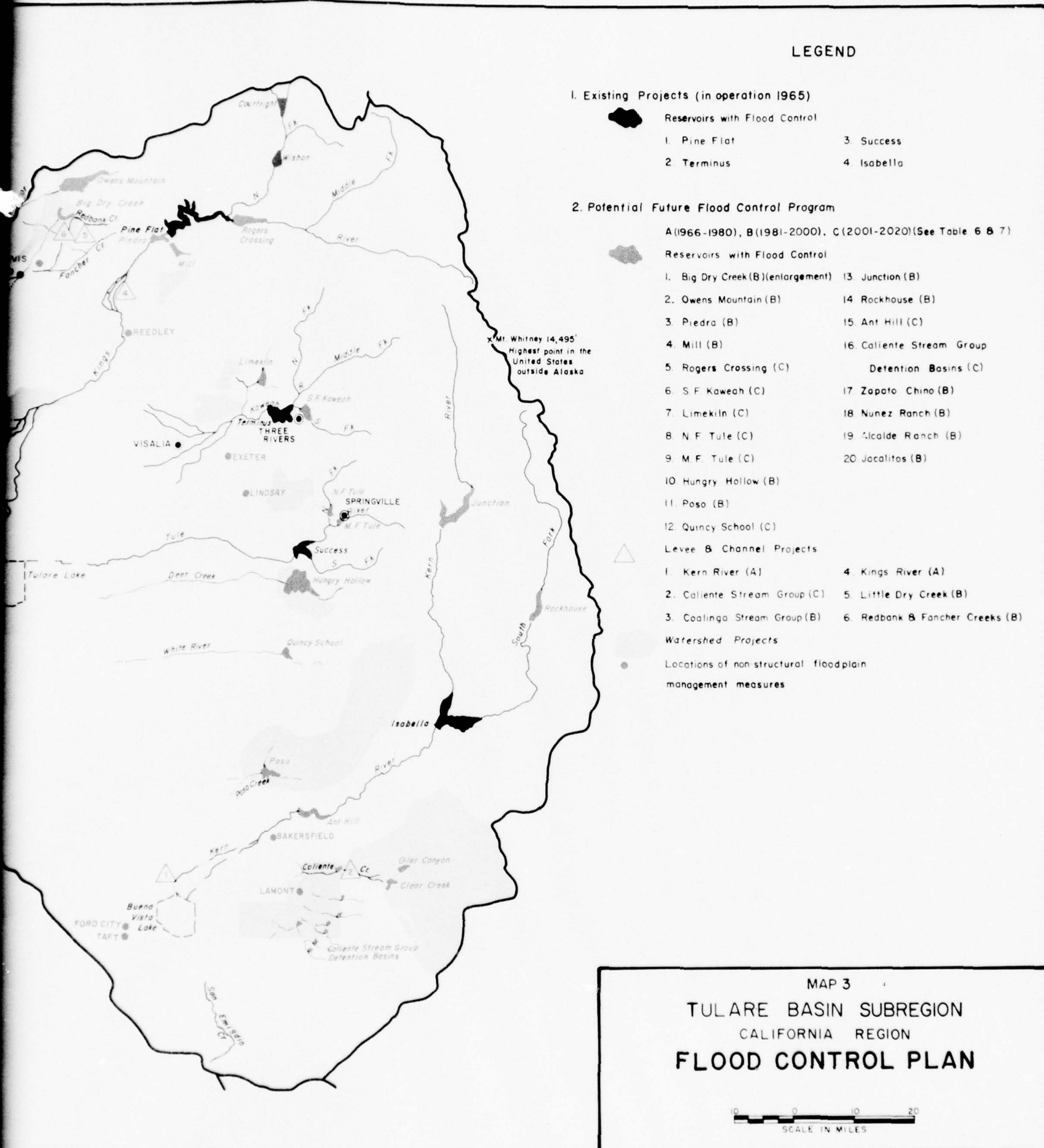
Study area/ stream	Location	Non-damaging flow 1/	Maximum flood of record: Date	Maximum flood of record: Flow: At time of occurrence	Maximum flood of record: Flow: Existing (1965) project conditions	Maximum flood of record: Flow: Future project conditions 2/: 1980	Maximum flood of record: Flow: Future project conditions 2/: 2000	Maximum flood of record: Flow: Future project conditions 2/: 2020	Flow of standard project flood: Existing (1965) project conditions	Flow of standard project flood: Future project conditions 2/: 1980	Flow of standard project flood: Future project conditions 2/: 2000	Flow of standard project flood: Future project conditions 2/: 2020	Flow of 100-year frequency flood: Existing (1965) project conditions	Flow of 100-year frequency flood: Future project conditions 2/: 1980	Flow of 100-year frequency flood: Future project conditions 2/: 2000	Flow of 100-year frequency flood: Future project conditions 2/: 2020
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Fresno County Stream Group																
Big Dry Creek	Big Dry															
	Inflow		Mar38	3	3	3	3	3	9	9	11	11	6	6	8	8
	Outflow	1	Mar38	3	3/	3/	1	1	2	2	1	1	1	1	1	1
Kings River Basin																
Kings River	Pine Flat															
	Inflow		19Nov50	91	91	91	91	91	250	250	250	250	156	156	156	156
	Outflow	13	19Nov50	91	11	11	11	11	39	39	39	39	19	19	19	19
Kaweah River Basin																
Kaweah River	Terminus															
	Inflow		6Dec66	105	105	105	105	105	115	115	115	115	98	98	98	98
	Outflow	6	6Dec66	6	6	6	6	6	22	22	22	6	13	13	13	6
Tule River Basin																
Tule River	Success															
	Inflow		6Dec66	61	61	61	61	61	72	72	72	72	62	62	62	62
	Outflow	3	6Dec66	8	8	8	8	3	11	11	11	3	8	8	8	3
Poso Creek Stream Group																
Poso Creek	Poso															
	Inflow		9Mar43	10	10	10	10	10	30	30	30	30	20	20	20	20
	Outflow	1	9Mar43	10	10	10	1	1	30	30	20	20	20	20	6	6
Kern River Basin																
Kern River	Isabella															
	Inflow		Dec66	120	120	120	71	71	148	148	90	90	79	79	42	42
	Outflow	10	Jan67	3	3	3	3	3	28	28	11	11	15	15	7	7
Caliente Creek Basin																
Caliente Creek	Sivert															
	Inflow		30Sep32	16	16	16	16	8	29	29	29	15	11	11	11	4
	Outflow	3/	30Sep32	16	16	16	16	3/	29	29	29	3/	11	11	11	3/
Westside Stream Group-Tulare Basin																
Los Gatos Stream Group	Los Gatos Group															
	Inflow		6Dec66	5	5	5	5	5	53	53	53	53	37	37	37	37
	Outflow	3/	6Dec66	5	5	5	3/	3/	53	53	12	12	37	37	5	5
Tulare Lakebed																
Tulare Lake	Tulare Lake															
	Inflow (1,000 ac-ft)	-	1906	2,000	500	500	180	0	1,200	975	505	220	800	660	370	120

1/ Under 1965 project conditions.
2/ Flows as modified by future projects likely to be in a future flood control program by the years 1980, 2000, and 2020.
3/ Less than 1,000 cfs.

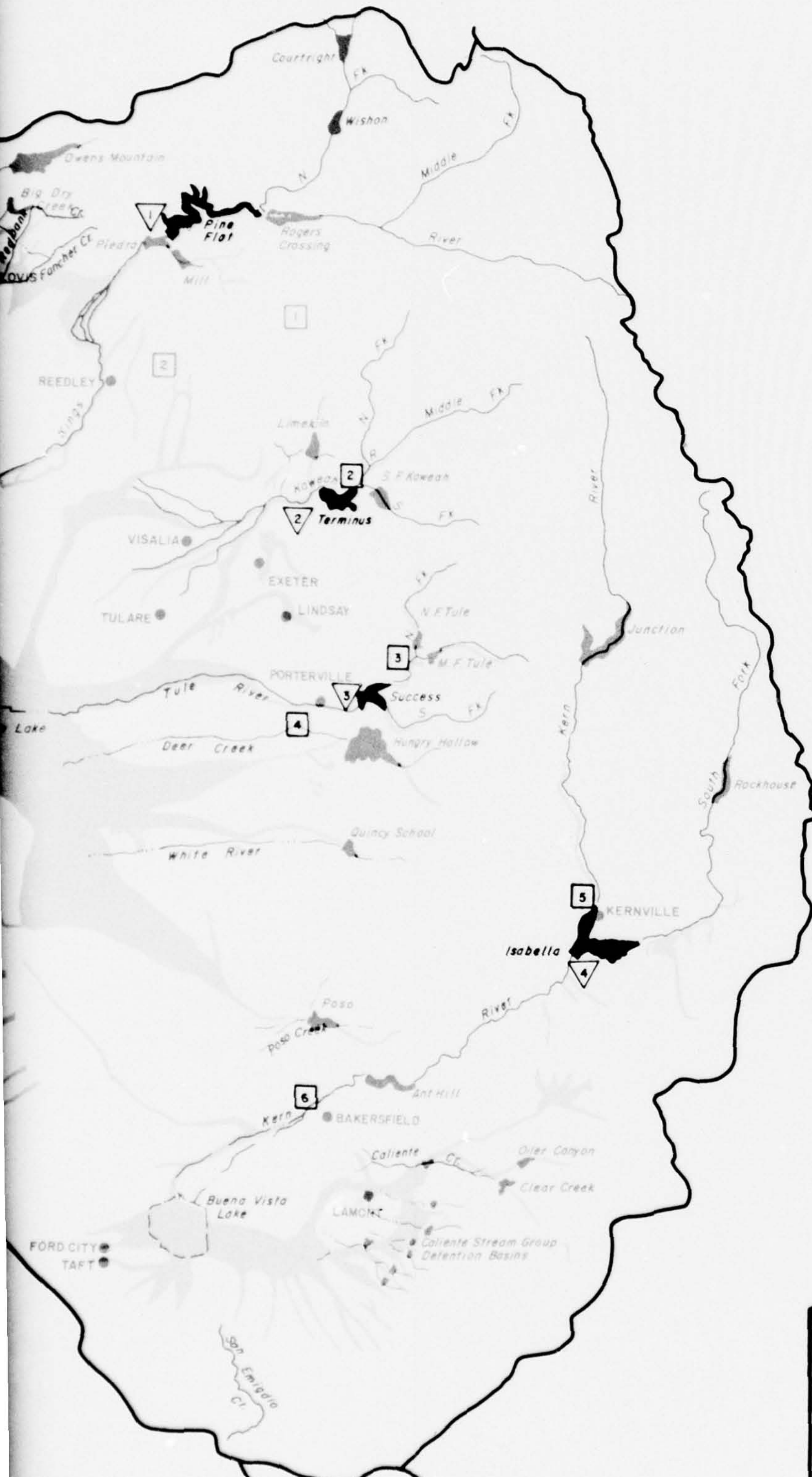

N
San Joaquin River
Redbank Cr
Fancher Cr.
Pine Flat
FRESNO
FRESNO COUNTY STREAM GROUP
Kings
VISAL
KAWEA
Los Gatos Cr
COALINGA
Warthon Cr
Jacalitos Cr
Zapato Chino Cr
WESTSIDE STREAM GROUP-TULARE BASIN
Tulare Lake
TULARE LAKE BED
TUL
POSO
ST
HYDROLOGIC SUB REGIONS
NC NORTH COASTAL
SF SAN FRANCISCO BAY
CC CENTRAL COASTAL
SC SOUTH COASTAL
SB SACRAMENTO BASIN
DC DELTA CENTRAL SIERRA
SJ SAN JOAQUIN BASIN
TB TULARE BASIN
NL NORTH LAHONTAN
SL SOUTH LAHONTAN
CD COLORADO DESERT
NC
NL
SB
SF
DC
SJ
CC
SL
SC
CD


LEGEND
1. Reservoir with Flood Control
2. Other Reservoir or Lake
3. Study Area Boundary
KINGS RIVER BASIN
Courtright
Wishon
Pine Flat
Fancher Cr
KAWEAH RIVER BASIN
VISALIA
THREE RIVERS
Terminus
Mt. Whitney 14,495'
Highest point in the
United States
outside Alaska
SPRINGVILLE
Success
TULE RIVER BASIN
Deer Creek
White River
POSO CREEK STREAM GROUP
Isabella
KERN RIVER BASIN
Poso Creek
BAKERSFIELD
Caliente Cr
CALIENTE CREEK BASIN
Buena Vista Lake
STREAMS TRIBUTARY TO
BUENA VISTA LAKE
San Emigdio Cr
MAP 2
TULARE BASIN SUBREGION
CALIFORNIA REGION
FLOOD CONTROL STUDY AREAS
10 0 10 20
SCALE IN MILES


N
Owens Mountain
Big Dry Creek
Redbank Cr
Pine Flat
Piedra
Mill
San Joaquin River
MENDOTA
CLOVIS
FRESNO
Fancher Cr
REEDLEY
Kings
VISALIA
Los Gatos
Nunez Ranch
COALINGA
Alcalde Ranch
Warthan Cr
Jacalitos Cr
Zapato Chino Cr
Zapato Chino
Tule
Tulare Lake
Deer Cr
White River
Buena Vista Lake
FORD CITY
TAFT
HYDROLOGIC SUB-REGIONS
NC NORTH COASTAL
SF SAN FRANCISCO BAY
CC CENTRAL COASTAL
SC SOUTH COASTAL
SB SACRAMENTO BASIN
DC DELTA-CENTRAL SIERRA
SJ SAN JOAQUIN BASIN
TB TULARE BASIN
NL NORTH LAHONTAN
SL SOUTH LAHONTAN
CD COLORADO DESERT


LEGEND
1. Existing Projects (in operation 1965)
Reservoirs with Flood Control
1. Pine Flat
2. Terminus
3. Success
4. Isabella
2. Potential Future Flood Control Program
A(1966-1980), B(1981-2000), C(2001-2020)(See Table 6 & 7)
Reservoirs with Flood Control
1. Big Dry Creek (B)(enlargement)
2. Owens Mountain (B)
3. Piedra (B)
4. Mill (B)
5. Rogers Crossing (C)
6. S.F. Kaweah (C)
7. Limekiln (C)
8. N.F. Tule (C)
9. M.F. Tule (C)
10. Hungry Hollow (B)
11. Poso (B)
12. Quincy School (C)
13. Junction (B)
14. Rockhouse (B)
15. Ant Hill (C)
16. Caliente Stream Group Detention Basins (C)
17. Zapato Chino (B)
18. Nunez Ranch (B)
19. Alcalde Ranch (B)
20. Jacalitos (B)
Levee & Channel Projects
1. Kern River (A)
2. Caliente Stream Group (C)
3. Coalinga Stream Group (B)
4. Kings River (A)
5. Little Dry Creek (B)
6. Redbank & Fancher Creeks (B)
Watershed Projects
Locations of non-structural floodplain management measures
Courtright
Wishon
Owens Mountain
Big Dry Creek
Redbank Cr
Pine Flat
Piedra
Fancher Cr
Mill
Rogers Crossing
Middle Fk
River
REEDLEY
Kings
Limekiln
S.F. Kaweah
Kaweah
Terminus
THREE RIVERS
VISALIA
EXETER
LINDSAY
SPRINGVILLE
N.F. Tule
M.F. Tule
Tule
Success
Tulare Lake
Deer Creek
Hungry Hollow
Junction
Kern River
South Fork
Rockhouse
White River
Quincy School
Isabella
Poso
Poso Creek
Ant Hill
BAKERSFIELD
Kern
Caliente Cr
Oiler Canyon
Clear Creek
LAMONT
Buena Vista Lake
FORD CITY
TAFT
Caliente Stream Group Detention Basins
San Emigdio Cr
X Mt. Whitney 14,495' Highest point in the United States outside Alaska
MAP 3
TULARE BASIN SUBREGION
CALIFORNIA REGION
FLOOD CONTROL PLAN
10 0 10 20
SCALE IN MILES


MENDOTA
FRESNO
CLOVIS
REEDLEY
Big Dry Creek
COALINGA
Los Gatos
Nunez Ranch
Alcalde Ranch
Tulare Lake
FORD CITY
HYDROLOGIC SUB-REGIONS
NC NORTH COASTAL
SF SAN FRANCISCO BAY
CC CENTRAL COASTAL
SC SOUTH COASTAL
SB SACRAMENTO BASIN
DC DELTA-CENTRAL SIERRA
SJ SAN JOAQUIN BASIN
TB TULARE BASIN
NL NORTH LAHONTAN
SL SOUTH LAHONTAN
CD COLORADO DESERT



LEGEND

1. Area Subject to Flooding

2. Major Urban Damage Centers

3. River Forecasting Points

River Stage (Existing)
1. Mendota Pool
2. Three Rivers
3. Springville
4. Porterville
5. Kernville
6. Bakersfield

River Stage (Future)
1. Miramonte
2. Orange Cove

Reservoir Inflow (Existing)
1. Pine Flat Reservoir
2. Terminus Reservoir
3. Success Reservoir
4. Isabella Reservoir

4. Existing Reservoir with Flood Control
1. Pine Flat Dam
2. Terminus
3. Success Res.
4. Isabella Dam

5. Other Reservoir or Lake

6. Potential Future Reservoir with Flood Control

MAP 4

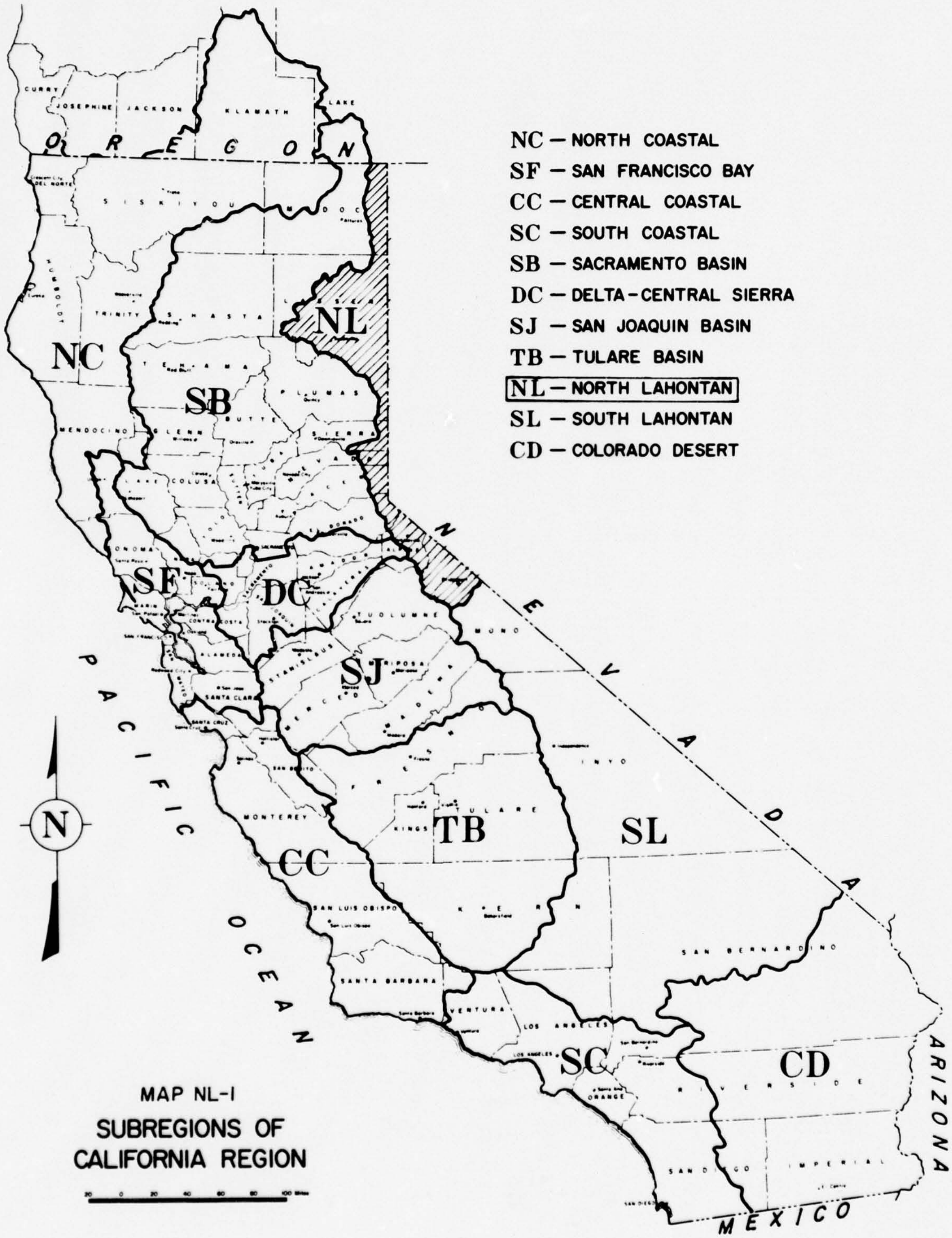
TULARE BASIN SUBREGION

CALIFORNIA REGION

FLOOD DAMAGE AREAS AND RIVER FORECAST SERVICE

10 0 10 20
SCALE IN MILES

NORTH LAHONTAN SUBREGION



MAP NL-1
SUBREGIONS OF CALIFORNIA REGION

NORTH LAHONTAN SUBREGION

General

The North Lahontan Subregion (NL) is situated in northeastern California. It extends generally from Oregon on the north to Bridgeport, Mono County, on the south, and from the crest of the Sierra Nevada on the west to the California-Nevada state line on the east. (See Map NL-1.) The subregion is about 270 miles long and 20 miles wide and comprises an area of 6,084 square miles.

The climate of the subregion varies widely because of differences in topography, elevation and exposure to moisture-bearing winds. Some sections of the subregion in the Sierra Nevada average 40 inches of precipitation per year while more desert areas receive only 3 inches. Temperatures also show wide seasonal variations with a summer mean monthly maximum temperature of 87 degrees and a winter mean monthly maximum temperature of 37 degrees. With the exception of the high mountain areas, summers are short and hot and winters are long but only moderately cold.

The subregion had an estimated total population of 39,000 in 1965. The economy is dependent upon agriculture, recreation, lumbering and mining. The principal agricultural activities are cattle raising and production of forage crops. The Lake Tahoe area has a large summer population and is an important year round recreation area.

Transportation facilities, with the exception of the Lake Tahoe area, are not extensive due to the sparse population and scattered land development. However, one major highway extends north and south through the subregion, and a number of state highways provide access to adjoining areas. South Lake Tahoe is the only city to which airlines maintain scheduled flights.

The subregion consists of the California portions of the Susan, Truckee, Carson, and Walker River Basins, and Surpise Valley. These areas have no outlets to the sea and stream courses terminate in lakes or playas that are remnants of ancient Lake Lahontan. Susan River flows generally southeasterly terminating in Honey Lake. The Carson and Walker Rivers originate in California but terminate in Carson Sink and Walker Lake, respectively, in Nevada. Truckee River, originating at Lake Tahoe, flows to Pyramid Lake in Nevada. Most of the streams draining Surprise Valley originate along the steep slopes of the Warner Mountains and discharge into Upper, Middle or Lower Alkali Lakes.

Additional information on the subregion can be found in Appendix II, "The Region."

For the investigation of present and future flood problems and the analysis of potential solutions, the subregion has been subdivided into the following study areas: Surprise Valley, Susan River Basin, Truckee River Basin, Carson River Basin and Walker River Basin. The principal streams in these areas are shown on Map 2.

History of Flooding

The North Lahontan Subregion, similar to other subregions in northern and central California, is periodically subject to widespread storms during the winter season from November through March. Floods are of three types: 1) those that occur during the late fall and winter months, primarily as a result of prolonged general rainstorms; 2) those that occur during the spring and early summer months, primarily as a result of the melting of the winter snowpack in the high areas of the Sierra Nevada; and 3) those that occur during the late spring through fall months as a result of intense local rainstorms. The most significant type is the late fall and winter floods caused by general rainstorms. On a subregional basis, the 1950-1951 and 1962-1963 floods are considered to be the most severe, although other floods may have caused higher flows on individual streams.

During the 1950-1951 flood, damages occurred as a result of intense winter rainstorms producing large streamflows on the Truckee, Carson, and Walker Rivers. About 5,000 acres were inundated during the flood and damages were nearly $800,000. The floods of 1962-1963 caused extensive damage in the Carson River Basin. About 18,700 acres were inundated and damages exceeded $800,000. Agricultural and public facility damages comprised over 80% of the total flood damage. The most severe floods of record occurred in December 1964-January 1965. Nearly $900,000 damage resulted from the inundation of about 20,000 acres, with the greatest damage occurring in the Truckee River Basin.

Flood fighting and cleanup costs under the various Federal programs were about $40,000 for the 1950-1951 flood and about $60,000 for the 1962-1963 flood. Damages from these and other significant recent floods in the subregion are tabulated on page NL-3 and are shown in more detail in Tables 1 and 2.

Flood year	Flood damages 1/ ($1,000): Forest & range resources & facilities	Agricultural & land	Residential & commercial	Industrial & utility	Public facilities	Total
1950-1951	367	157	24	245 2/		793
1955-1956	322	31	0	21	276	650
1962-1963	130	273	18	1	400	822
1964-1965	311	217	58	18	278	882

1/ Based on prices and project and economic conditions at time of occurrence of flood.

2/ Total damages including industrial, utility, and public facilities.

Peak flows of maximum floods of record, 100-year floods and standard project floods for selected stations in the subregion are shown in Table 11.

Present Status of Flood Control Improvements

The existing flood control improvements within the subregion comprise a variety of measures to reduce flood damages. (See Map 3.) They included flood forecasting, flood control reservoirs, minor channel projects and tributary watershed treatment. Existing measures, which provide only minor protection to the area as a whole, are described in more detail in following paragraphs. About 5% of the area subject to flooding is protected.

Flood forecasts are prepared and distributed by the Federal-State River Forecast Center in Sacramento. These forecasts involve principally: (1) inflow to Lake Tahoe to allow operators to make releases that will prevent the lake from exceeding the maximum elevation (6,229.1 feet) set by Federal decree in September 1944; (2) inflow forecasts for regulation of Prosser and Boca Reservoirs; and (3) river stage forecasts at downstream points along the Truckee, Carson, Walker, and Susan Rivers. Forecast points are shown on Map 4.

Prosser Reservoir is the only reservoir in the subregion operated for flood control. It has a drainage area of 50 square miles and provides a maximum of 20,000 acre-feet of flood control storage during the most critical flood situations. Map 3 shows Prosser Reservoir and the other existing structural works referred to in this report. Other reservoirs in the

subregion, though not having flood control as a designated function, provide incidental, but often significant flood control benefits. Reservoirs of this type are:

Reservoir	Stream	Construction agency or operator
Boca	Little Truckee River	Washoe County Conservation District
Bridgeport	East Walker River	Walker River Irrigation District
Tahoe	Truckee River	Federal Court Watermaster

The only channel project in the subregion is on the Truckee River. It is less than 1 mile long and is immediately downstream from Lake Tahoe outlet.

Work in watershed areas has been mainly local land treatment. Individual landowners and groups of farmers and ranchers have installed these measures, working with some aid from various State and Federal agencies.

The Flood Plain Management Services Program is covered in detail in the Regional Summary of this appendix. Under the program, flood hazard information is being furnished to local agencies for use in evaluating the flood hazard of individual sites.

The flood control measures existing in 1965 prevented about $1,500,000 in flood damages during the 1962-1963 flood and would have prevented about $250,000 in flood damages during the 1950-1951 flood. It is estimated that annual damages prevented by existing measures exceed $15,000. Additional details are included in Table 2.

Flood problems in the North Lahontan Subregion are much in evidence. In contrast to many of the other subregions in the California Region, this subregion does not have a highly developed flood protection system. Flooding occurs along many of the streams with resulting damages to agricultural and urban properties. The problems are especially serious along Bidwell Creek in Surprise Valley and the Susan, Truckee, Carson, and Walker Rivers. Much of the flood problem in tributary watershed areas has not been alleviated.

As indicated in the tables on flood damages (Tables 1, 3, and 4) considerable land damage, including channel and bank erosion, occurs in many of the areas subject to inundation. Lake Tahoe, Susan River and the Surprise Valley streams in particular are areas of critical erosion problems. In these areas over 100 acres of stream-adjacent land are lost annually; up to 50% of the sediment production is streambank erosion. This is particularly serious in the Tahoe area where vulnerable creekside land is undergoing urban development. The problem in this part of the region is compounded by summer convection storms which produce high intensity rainfall

with high volume runoffs. The most severely affected reaches of stream channel are the upper alluvial fans where the channels emerge from the hills. In the subregion as a whole, there are about 4,300 miles of channel (or 8,600 bank miles). Of these, over 1,120 bank miles have some erosion problems with about 430 miles classed as "serious". Average annual erosion damage is over $150,000 with the sediment produced causing an additional $280,000 damage annually.

The aforementioned flood problems result in average annual damages as follows:

Study area	Estimated average annual damages ($1,000) 1/
Surprise Valley	455
Susan River Basin	331
Truckee River Basin	827
Carson River Basin	19
Walker River Basin	406
Total North Lahontan Subregion	2,038

1/ Based on 1965 prices, economic conditions and project conditions.

Additional details are contained in Tables 3 and 4 for the subregion as a whole and in Table 9 for urban areas. Major urban damage centers and areas of the subregion subject to flooding are shown on Map 4.

Future Needs

It is evident from an examination of current (1965) flood problems that additional flood control measures are required. It is estimated that average annual flood damages in the subregion (based on 1965 prices and conditions) amount to $2.0 million. The flood problems of the area will increase in the future due to the pressures of population and economic growth and resultant increases in the use of land. The population of the North Lahontan Subregion is projected to increase from 39,000 in 1965 to 51,000 in 1980, 82,000 in 2000 and 152,000 in 2020 (base plan projections). Average annual flood damages are expected to increase to about $3.0 million by 1980, to $5.3 million by 2000, and to $11.3 million by 2020 if additional flood control measures are not provided. Estimated damage for existing and future conditions is contained in Tables 5 and 9a.

Measures Required to Satisfy Future Needs

Improved flood forecasting will be a part of a comprehensive flood control program. A well coordinated system of forecasting and project operation is necessary to operate the projects effectively. Some additional forecast procedure development will be required in this subregion as new projects are developed. The subregion lacks telemetered hydrologic data. Improvement will have to be made in the data networks to upgrade the quality and timing of the forecasts. The required improvements to the flood forecasting system are estimated to cost $130,000 for the 1966-1980 period, $120,000 for the 1981-2000 period, and $110,000 for the 2001-2020 period.

Floodwater storage in reservoirs will be an important feature in a future flood control program especially because such storage would also reduce flood damages further downstream in Nevada (Great Basin Region). An additional 220,000 acre-feet of flood control capacity are required in reservoirs in the subregion as follows:

Study area/ time frame in which needed	Reservoir	Stream	Flood control capacity (ac.-ft.)	Drainage area (sq. miles)
Surprise Valley				
1981-2000	Detention Structures (2)	(Various)	2,000	44
Susan River Basin				
1966-1980	Detention Structure	No Name	4,000	96
1981-2000	Detention Structures (7)	(Various)	20,000	281
Truckee River Basin				
1966-1980 1/	2/ Stampede	Little Truckee R.	22,000	137
1966-1980 1/	2/ Boca	Little Truckee R.	8,000	172
1966-1980 1/	2/ Martis Creek	Martis Creek	15,000	39
1966-1980	Detention Structure	No Name	1,000	1
1981-2000	Detention Structures (2)	(Various)	7,000	38
2001-2020	Detention Structures (2)	(Various)	8,000	32

Study area/ time frame in which needed	Reservoir	Stream	Flood control capacity (ac.-ft.)	Drainage area (sq. miles)
Carson River Basin				
1981-2000	2/Hope Valley	W. Fork Carson R.	20,000	52
Walker River Basin				
1966-1980	Detention Structures (2)	(Various)	13,000	88
1981-2000	2/Pickle Meadow	W. Fork Walker R.	100,000	115
		TOTAL	220,000	

1/ Under construction or funded for construction as of FY 1970.
2/ Also provides flood control for areas in Nevada (Great Basin Region).

These reservoirs are shown on Map 3 and additional information on flood control storage is contained in Table 6. Estimated costs for additional flood control capacity are $11.8 million for the 1966-1980 period, $18.6 million for the 1981-2000 period, and $2.1 million for the 2001-2020 period.

In addition to these reservoirs, preliminary studies indicate that levee and channel work is desirable in the following areas:

Study area	Levees (Bank Miles)	Channels (Miles)
Surprise Valley		
1966-1980	0	33
1981-2000	0	7
2001-2020	10	10
Susan River Basin		
1981-2000	0	8
Truckee River Basin		
1966-1980	0	1
1981-2000	0	11
2001-2020	0	1
Walker River Basin		
1966-1980	0	5
TOTAL	10	76

The approximate location of levees and channel work are indicated on Map 3 and additional details are included in Table 7. The estimated costs for required levee and channel work are $11.6 million for the 1966-1980 period, $5.6 million for the 1981-2000 period, and $3.7 million for the 2001-2020 period.

The structural measures will be complemented by non-structural land treatment measures for soil and water conservation. In this subregion, the land treatment measures will be primarily range seeding, critical area planting, brush control, rotation-deferred grazing and fire prevention. Map 3 indicates potential watershed projects. Estimated costs and acres of land treatment measures are summarized below:

Land Treatment	1966-1980	1981-2000	2001-2020
Thousand acres	221	97	27
Thousand dollars	470	490	290

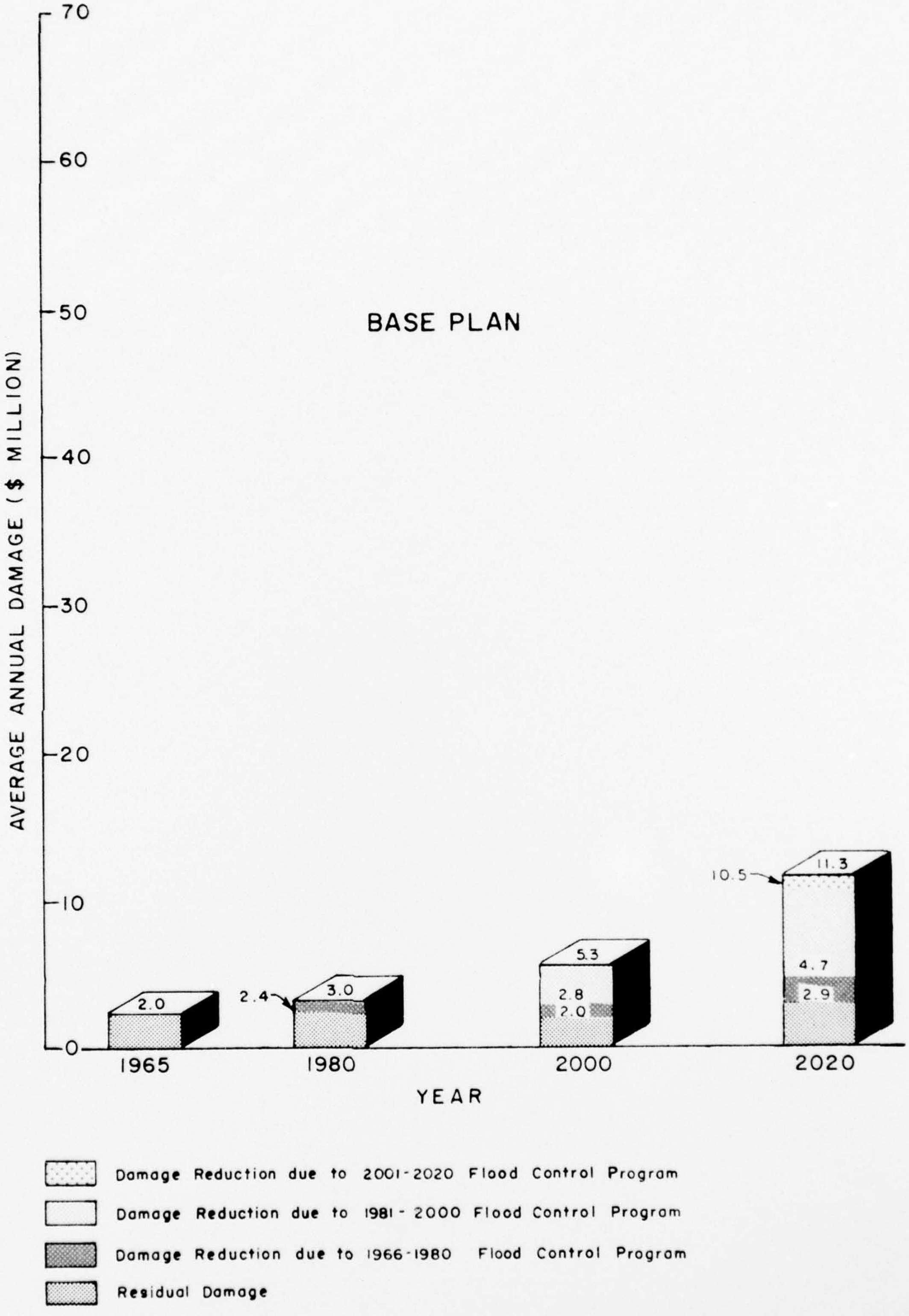
Non-structural flood plain management measures will be a part of community planning to reduce existing and anticipated flood problems. Flood plain zoning during 1966-1980 time frame appears to be the most practical means available. After 1980 flood proofing and other measures will also be practical in the Susan River Basin. Table 9b shows the reduction in damages expected from such measures. Communities in this subregion with populations in excess of 2,500 with significant flood problems include Susanville, South Lake Tahoe, and Tahoe City. Many communities with expanding populations are expected to have flood problems in the future and will be studied as their needs become known. Flood plain information reports for Tahoe City, South Lake Tahoe, and Susanville are scheduled for completion by 1980. Comprehensive flood damage prevention planning and implementation of flood plain management measures would follow in each flood problem area identified. Non-structural flood plain management measures along approximately 20 stream miles could be implemented for the communities named above. Map 3 shows principal areas for which non-structural flood plain management measures are proposed.

Costs of future non-structural flood plain management measures are estimated at $1.3 million for the 1966-1980 period, $2.8 million for the 1981-2000 period, and $4.0 million for the 2001-2020 period.

Potential to Satisfy Future Needs

The flood control program presented herein would reduce the projected average annual damages $0.6 million by 1980, $3.3 million by 2000, and $8.4 million by 2020 at an estimated installation cost of $25.3 million for the period 1966-1980, $27.6 million for 1981-2000, and $10.2 million

for 2001-2020. Estimated annual OM&R costs for the 1966-1980, 1981-2000 and 2001-2020 portions of the flood control program are $0.28 million, $0.38 million and $0.28 million (See Tables 10, 10a and 10b). The effect of the potential flood control program on future damages is shown in Table 8 and graphically on Figure NL-1, and its effect on flood flows is shown in Table 11.



CALIFORNIA REGION
COMPREHENSIVE FRAMEWORK STUDY

PROJECTED AVERAGE ANNUAL FLOOD DAMAGES

(1965 PRICES AND PROJECT CONDITIONS-DATA FROM TABLES 5 & 8)

TABLE 1

NORTH LAHONTAN SUBREGION OF THE CALIFORNIA REGION

Historical Flood Data

Study area	Flood	Location/ flow (cfs)	Area inundated (1,000 acres)	Flood damages 1/ - ($1,000) Forest & range resources	Forest & range facilities	Crop & pasture	Other agricultural	Land	Residential & commercial	Industrial & utility	Public facilities	Total
1	2	3	4	5	6	7	8	9	10	11	12	13
Surprise Valley	Dec64		2	0	0	18	20	70	2	0	81	191
Susan River Basin	Jan63	At Susanville 3,400	18.5	0	0	48	70	74	2	0	60	254
	Dec64	At Susanville 5,100	15.0	1	19	20	40	48	5	0	0	133
Truckee River Basin	Feb63	Above Boca Reservoir 13,300	1.5	0	130	0	0	0	2	1	38	171
	Dec64	Above Boca Reservoir 10,600	1.2	0	291	0	1	0	51	18	194	555
Carson River Basin	Dec55	E. Fork at Gardnerville 17,600	0.4	0	0	2	8	2	0	0	53	65
	Feb63	E. Fork at Gardnerville 13,500	0	0	0	0	0	0	0	0	59	59
Walker River Basin	Nov50	W. Walker near Coleville 6,200	0.3	0	0	15	58	55	5	0	211	344
	Dec55	W. Walker near Coleville 5,200	4.5	0	0	11	52	44	0	0	128	235

1/ Data based on prices and project and economic conditions at time of occurrence of flood.

TABLE 2

NORTH LAHONTAN SUBREGION OF THE CALIFORNIA REGION

Flood Damage 1/

Study area	Flood	Location/ flow (cfs)	Total damages - ($1,000) At time of flood 2/ Actual damage	Damage without flood control projects	Damage prevented by flood control projects 4/	1965 economic conditions & prices 3/ Damage with 1965 project conditions	Damage without flood control projects	Damage prevented by 1965 projects 5/
1	2	3	4	5	6	7	8	9
Surprise Valley	Dec64	Varied	191	191	0	191	191	0
Susan River Basin	Dec64	At Susanville 5,100	133	133	0	133	133	0
Truckee River Basin	Jan-Feb 63	Boca Inflow 13,300 (Outflow 2,000)	171	220	49	171	220	49
Carson River Basin	Dec55	E. Fork at Gardnerville 17,600	65	65	0	119	119	0
Walker River Basin	Nov50	Near Coleville 6,200	344	344	0	392	392	0

1/ Maximum flood for which data are available.
2/ Data based on prices and project and economic conditions at time of occurrence of flood.
3/ Data based on recurrence of original flood.
4/ Column 6 = column 5 - column 4.
5/ Column 9 = column 8 - column 7.

TABLE 3

NORTH LAHONTAN SUBREGION OF THE CALIFORNIA REGION

Estimated Flood Damage for
the 100-Year Frequency Flood 1/
for Selected Streams

Study area/ stream	Area inundated (1,000 acres)	Flood damage 2/ - ($1,000) Forest & range resources	Forest & range facilities	Crop & pasture	Other agricultural	Land	Residential & commercial	Industrial & utilities	Public facilities	Total
1	2	3	4	5	6	7	8	9	10	11
Surprise Valley Bidwell Creek	3.5	1	0	27	436	946	40	40	130	1,620
Susan River Basin Susan River	19.9	18	30	36	410	198	350	110	290	1,442
Truckee River Basin Truckee River	2.0	0	383	0	0	96	2,292	252	587	3,610
Carson River Basin Carson River	0.5	0	0	13	4	62	0	0	101	180
Walker River Basin Walker River	8.9	0	0	69	870	398	440	144	45	1,966

1/ See Table 11 for magnitude of 100-year flood at selected stations.
2/ Based on July 1965 prices, economic conditions, and project conditions.

TABLE 4

NORTH LAHONTAN SUBREGION OF THE CALIFORNIA REGION

Estimated Average Annual Flood Damage

Study area (principal stream)	Flood damage 1/ - ($1,000) Forest & range resources	Forest & range facilities	Crop & pasture	Other agricultural	Land	Residential & commercial	Industrial & utilities	Public facilities	Study area totals
1	2	3	4	5	6	7	8	9	10
Surprise Valley (Bidwell Creek)	Neg.	0	8	131	284	6	6	20	455
Susan River Basin (Susan River)	4	6	19	143	69	38	13	39	331
Truckee River Basin (Truckee River)	0	77	0	0	17	593	46	94	827
Carson River Basin (Carson River)	0	0	2	0	11	0	0	6	19
Walker River Basin (Walker River)	0	0	19	244	112	22	7	2	406
Total North Lahontan Subregion	4	83	48	518	493	659	72	161	2,038

1/ Damages based on July 1965 prices, economic conditions, and project conditions.

Base Plan

TABLE 5

NORTH LAHONTAN SUBREGION OF THE CALIFORNIA REGION

Summary of Estimated Average Annual Flood Damage for Present
and Future Conditions of Economic Development
with Existing Flood Control Measures

Study area (principal stream)	Average annual flood damages 1/ - ($1,000)			
	1965 economic conditions 2/	1980 economic conditions	2000 economic conditions	2020 economic conditions
1	2	3	4	5
Surprise Valley (Bidwell Creek)	455	568	805	1,089
Susan River Basin (Susan River)	331	445	696	1,272
Truckee River Basin (Truckee River)	827	1,372	2,851	7,288
Carson River Basin (Carson River)	19	31	79	169
Walker River Basin (Walker River)	406	542	908	1,453
Total North Lahontan Subregion	2,038	2,958	5,341	11,271

1/ Damages based on July 1965 prices and project conditions, and estimated economic conditions for the year shown.
2/ Figures in column 2 are from column 10 of Table 4

Base Plan

TABLE 6

NORTH LAHONTAN SUBREGION OF THE CALIFORNIA REGION

Summary of Flood Control Capacity for Existing
and Future Reservoirs

Study area	Flood control capacity 1/ - (1,000 ac-ft)				
	Existing projects (1965)	Projects 1966-1980 2/	Projects 1981-2000 2/	Projects 2001-2020 2/	Total projects as of 2020
1	2	3	4	5	6
Surprise Valley	0	0	2	0	2
Susan River Basin	0	4	20	0	24
Truckee River Basin	20	46	7	8	81
Carson River Basin	0	0	20	0	20
Walker River Basin	0	13	100	0	113
Total North Lahontan Subregion	20	63	149	8	240

1/ Maximum flood control capacity. Does not include surcharge storage.
2/ Includes only reservoirs controlling the 100-year flood, or better, at the damsite above urban areas and reservoirs controlling at least the 10-year flood at the damsite where only rural areas are to be protected.

TABLE 7

Base Plan

NORTH LAHONTAN SUBREGION OF THE CALIFORNIA REGION

Summary of Levee and Channel Flood Protection Projects
- Existing and Future -

Study area	Levee and channel projects									
	Existing projects (1965)		Projects 1966-1980 1/		Projects 1981-2000 1/		Projects 2001-2020 1/		Total projects as of 2020	
	Levees (miles)	Channels (miles)	Levees (miles)	Channels (miles)	Levees (miles)	Channels (miles)	Levees (miles)	Channels (miles)	Levees (miles)	Channels (miles)
1	2	3	4	5	6	7	8	9	10	11
Surprise Valley	0	0	0	33	0	7	10	10	10	50
Susan River Basin	0	0	0	0	0	8	0	0	0	8
Truckee River Basin	0	1	0	1	0	11	0	1	0	14
Walker River Basin	0	0	0	5	0	0	0	0	0	5
Total North Lahontan Subregion	0	1	0	39	0	26	10	11	10	77

1/ Includes only projects giving 100-year flood protection, or better, to urban areas and at least 10-year flood protection to agricultural areas.

TABLE 8

Base Plan

NORTH LAHONTAN SUBREGION OF THE CALIFORNIA REGION

Estimated Average Annual Flood Damage and Damage Reduction
- Present and Future Economic Conditions -

Study area (principal stream)	Total damages - 1965 prices ($1,000)									
	1965 economic & project conditions 1/	1980 economic conditions			2000 economic conditions			2020 economic conditions		
		W/1965 project conditions 2/	Reduction in damages due to 1966-1980 flood control program 3/	Residual damage W/ 1966-1980 program 4/	W/1966-1980 program	Reduction in damages due to 1981-2000 flood control program 3/	Residual damage W/ 1981-2000 program 5/	W/1981-2000 program	Reduction in damages due to 2001-2020 flood control program 3/	Residual damage W/ 2001-2020 program 6/
1	2	3	4	5	6	7	8	9	10	11
Surprise Valley (Bidwell Creek)	455	568	273	295	419	182	237	320	39	281
Susan River Basin (Susan River)	331	445	60	385	626	221	405	675	149	526
Truckee River Basin (Truckee River)	827	1,372	110 7/	1,262	2,626	1,912	714	1,751	567	1,184
Carson River Basin (Carson River)	19	31	0	31	79	14 8/	65	135	0	135
Walker River Basin (Walker River)	406	542	111	431	724	205 8/	519	830	0	830
Total North Lahontan Subregion	2,038	2,958	554	2,404	4,474	2,534	1,940	3,711	755	2,956

1/ Figures shown in column 2 are from column 10 of Table 4 and are also shown in column 2 of Table 5.
2/ Figures in column 3 are from column 3 of Table 5.
3/ Includes structural and non-structural measures.
4/ Column 5 = column 3 - column 4.
5/ Column 8 = column 6 - column 7.
6/ Column 11 = column 9 - column 10.
7/ Projects provide an additional damage reduction of about $374,000 in Nevada (Great Basin Region).
8/ Projects provide an additional damage reduction of about $52,000 in Nevada (Great Basin Region).

TABLE 9

NORTH LAHONTAN SUBREGION OF THE CALIFORNIA REGION

Estimated Average Annual Flood Damage for Urban Areas with Significant Flood Problems

Study area/ stream	Damage center	Average annual flood damages ($1,000) 1/ Residential	Commercial	Industrial & utilities	Public facilities	Total
1	2	3	4	5	6	7
Susan River Basin						
Susan River	Susanville	20	10	8	12	50
Truckee River Basin						
Truckee River	Tahoe City	2	1	1	5	9
Upper Truckee River Trout Creek	South Lake Tahoe	4	2	1	8	15
Total North Lahontan Subregion		26	13	10	25	74

1/ Damages are based on July 1965 prices, economic conditions, and project conditions.

TABLE 9a

NORTH LAHONTAN SUBREGION OF THE CALIFORNIA REGION

Summary of Estimated Average Annual Flood Damage for Urban Areas with Significant Flood Problems
- Present and Future Conditions of Economic Development with Existing Flood Control Measures -

Study area/ stream	Damage center	Average annual flood damages 1/ - ($1,000) 1965 economic conditions 2/	1980 economic conditions	2000 economic conditions	2020 economic conditions
1	2	3	4	5	6
Susan River Basin					
Susan River	Susanville	50	90	181	469
Truckee River Basin					
Truckee River	Tahoe City	9	18	40	116
Upper Truckee River & Trout Creek	South Lake Tahoe	15	29	69	183
Total North Lahontan Subregion		74	137	290	768

1/ Damages based on July 1965 prices and project conditions, and estimated economic conditions for the year shown.
2/ Figures in column 3 are from column 7, "Total", shown on Table 9.

TABLE 9b

NORTH LAHONTAN SUBREGION OF THE CALIFORNIA REGION

Estimated Average Annual Flood Damage and Damage Reduction for Urban Areas with Significant Flood Problems
- Present and Future Economic Conditions -

Study area/ stream	Damage center	Total damages - 1965 prices ($1,000): 1965 economic & project conditions 1/	1980 economic conditions: W/1965 project conditions 2/	1980: Reduction due to 1966-1980 program: Non-structural measures	1980: Reduction due to 1966-1980 program: Structural measures	1980: Residual damage w/1966-1980 program 3/	2000 economic conditions: W/1966-1980 program	2000: Reduction due to 1981-2000 program: Non-structural measures	2000: Reduction due to 1981-2000 program: Structural measures	2000: Residual damage w/1981-2000 program 4/	2020 economic conditions: W/1981-2000 program	2020: Reduction due to 2001-2020 program: Non-structural measures	2020: Reduction due to 2001-2020 program: Structural measures	2020: Residual damage w/2001-2020 program 5/
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Susan River Basin														
Susan River	Susanville	50	90	32	0	58	149	73	30	46	119	58	0	61
Truckee River Basin														
Truckee River	Tahoe City	9	18	7	0	11	33	18	0	15	91	70	0	21
Upper Truckee River & Trout Creek	South Lake Tahoe	15	29	11	0	18	58	32	0	26	140	106	0	34
Total North Lahontan Subregion		74	137	50	0	87	240	123	30	87	350	234	0	116

1/ Figures shown in column 3 are from column 7 of Table 9 and are also shown in column 3 of Table 9a.
2/ Figures in column 4 are from column 4 of Table 9a.
3/ Column 7 = column 4 - column 5 - column 6.
4/ Column 11 = column 8 - column 9 - column 10.
5/ Column 15 = column 12 - column 13 - column 14.

TABLE 10

NORTH LAHONTAN SUBREGION OF THE CALIFORNIA REGION

Estimated Costs of Future Flood Control Program
- [illegible] to 1980 -
($1,000)

Study area	Levees & channels: Federal: Installation costs	Levees & channels: Federal: Annual OM&R costs	Levees & channels: Non-Federal: Installation costs	Levees & channels: Non-Federal: Annual OM&R costs	Flood control reservoirs: Federal: Installation costs	Flood control reservoirs: Federal: Annual OM&R costs	Flood control reservoirs: Non-Federal: Installation costs	Flood control reservoirs: Non-Federal: Annual OM&R costs	Non-structural measures: Federal: Installation costs	Non-structural measures: Federal: Annual OM&R costs	Non-structural measures: Non-Federal: Installation costs	Non-structural measures: Non-Federal: Annual OM&R costs
1	2	3	4	5	6	7	8	9	10	11	12	13
Surprise Valley	10,800	0	200	83	0	0	0	0	20	3	10	1
Susan River Basin	0	0	0	0	220	0	290	1	110	14	890	10
Truckee River Basin	340	0	30	3	10,310	45	180	17	90	30	480	9
Carson River Basin	0	0	0	0	0	0	0	0	130	25	10	5
Walker River Basin	200	0	30	2	800	0	60	3	80	16	30	11
Total North Lahontan Subregion	11,340	0	260	88	11,330	45	530	21	430	88	1,420	36

Base Plan

TABLE 10a

NORTH LAHONTAN SUBREGION OF THE CALIFORNIA REGION

Estimated Costs of Future Flood Control Program
- 1981 to 2000 -
($1,000)

Study area	Levees & channels: Federal: Installation costs	Levees & channels: Federal: Annual OM&R costs	Levees & channels: Non-Federal: Installation costs	Levees & channels: Non-Federal: Annual OM&R costs	Flood control reservoirs: Federal: Installation costs	Flood control reservoirs: Federal: Annual OM&R costs	Flood control reservoirs: Non-Federal: Installation costs	Flood control reservoirs: Non-Federal: Annual OM&R costs	Non-structural measures: Federal: Installation costs	Non-structural measures: Federal: Annual OM&R costs	Non-structural measures: Non-Federal: Installation costs	Non-structural measures: Non-Federal: Annual OM&R costs
1	2	3	4	5	6	7	8	9	10	11	12	13
Surprise Valley	570	0	30	10	2,730	0	70	14	40	7	20	3
Susan River Basin	1,320	0	90	36	5,000	0	690	23	180	30	1,920	21
Truckee River Basin	2,950	0	590	48	4,750	0	600	18	90	48	930	17
Carson River Basin	0	0	0	0	3,000	10	0	0	60	33	20	10
Walker River Basin	0	0	0	0	1,800	4	0	0	70	28	40	21
Total North Lahontan Subregion	4,840	0	710	94	17,280	14	1,360	55	440	146	2,930	72